



Identifying public trust building priorities of gene editing in agriculture and food

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Abstract

Gene editing in agriculture and food (GEAF) is a nascent development with few products and is unfamiliar among the wider US public. GEAF has garnered significant praise for its potential to solve for a variety of agronomic problems but has also evoked controversy regarding safety and ethical standards of development and application. Given the wake of other agribiotechnology debates including GMOs (genetically modified organisms), this study made use of 36 in-depth key interviews to build the first U.S. based typology of proponent and critic priorities for shaping public trust in GEAF actors and objects. Key organizational actors provide early and foundational messaging, which is likely to contribute heavily to public salience, comprehension, and decision-making as potential consumers reflect upon their experiences, envision future outcomes, and consider the reputation of those trying to influence them. As is documented in our results, the trust-building priorities of these groups often stand in opposition to one another and are influenced by distinct motivations for how the public will come to trust or distrust GEAF actors and objects as more products are developed and enter the market.

Keywords Gene edited foods · Trust · Trust building · CRISPR

Introduction

Biotechnology promises many benefits given recent advancements in gene editing techniques (CAST 2018; Shukla-Jones et al. 2018). Novel genome editing tools such as CRISPR-Cas9 have been reported to be considerably faster, cheaper, and more precise than traditional selective breeding (Bain et al. 2020; NASEM 2016; Pirscher et al. 2018; Shukla-Jones et al. 2018). The application of gene editing in agriculture and food (GEAF) has also garnered significant praise as a potential means to solve a variety of agronomic, food security, and sustainability problems (Abdallah et al. 2015; Chen et al. 2019; Georges and Ray 2017; Haque et al. 2018). These technologies allow scientists to produce novel traits for food and agricultural products, and developers are currently seeking ways to increase yield or nutritional content, delay spoilage, and improve resilience to drought and disease. In March 2019, the first gene-edited food, a soybean oil free from trans fats and which boasts a longer shelf life than conventional soybean oil, was released for limited use with little public concern, deliberation, or major media coverage and has since been taken off the market (Dahlstrom et al. 2022).

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Biotechnology developers assert that gene-edited products are distinct from previous genetically modified organisms (GMO) for human and animal consumption (GM food). This distinction, according to developers, is predicated on the ability of new genome editing tools to make genomic manipulations within sexually compatible species, which they argue are distinct from manipulations of GMOs. Many proponents see the emergence of genome editing techniques as an opportunity to re-focus priorities for cultivating trust among the larger consumer citizenries. Proponents seek to ensure that GEAF avoid the intense public controversy GMOs faced, which they argue resulted in ‘burdensome’ regulations, trade restrictions, limited international production and trade of GMOs, and diminished opportunity to realize the benefits of GMOs (Bain and Dandachi 2014; Bain et al. 2020; CAST 2021; Schurman and Munro 2010). However, other groups and individuals are skeptical of this distinction and maintain that food products created from genome editing tools are equivalent to GMOs, with some critics labeling all products created through genomic editing as “GMO 2.0” (Kelam 2017). Thus, the current era of biotechnology development in agriculture and food follows from a longer history of contestation over GMOs and many debates, controversies, and uncertainties remain (Selva et al. 2021). The current debate is also marked by recognition of the failings of GMOs to deliver their varied promises for public benefits. As such, many developers now seek to transform their priorities for building consumer trust—that is, trust in their organizations, in the process of gene editing itself as a means of producing societal benefits, and ultimately in gene-edited food and agricultural products themselves. Annual events, such as CRISPRcon: Conversations on Science, Society and the Future of Gene Editing, started in 2017 to bring together interested publics, including scientists, businesspeople, farmers, and regulators to discuss developments and issues related to the CRISPR-Cas9 gene editing tool. More critical voices have complained that forums such as CRISPRcon represent “choreographed consensus” around the use of CRISPR, which serve to silence opposing views (Arora et al. 2019).

Like other food and agriculture technologies, realizing GEAF’s potential will partially depend on whether the public ultimately accepts or rejects it, and trust in prominent actors who advocate for or criticize GEAF is likely to be a key driver of that decision (Cummings and Peters 2022a, b; Cummings et al. 2018; Friedrichs et al. 2019; Lindberg et al. 2023). Over the last decade, some scholars have argued that trust in GEAF will be informed by factors that extend beyond technical risks and benefits (Dietz 2013; Kuzma and Kokotovich 2011; NASEM 2017; Will et al. 2022). Reporting on the first representative survey study of public opinion of gene-edited foods in the United States, Cummings and

Peters (2022a) recently identified that acceptance of GEAF is in an emergent stage. They found that trust in major institutions, including the biotechnology industry and advocacy and alternative agriculture organizations, play a significant role in the publics’ willingness to eat and purposeful avoidance of gene-edited foods, and they expect that the “public’s willingness to eat and purposeful avoidance of gene-edited food will change as they are engaged more readily on the developmental process and products in this area” (Cummings and Peters 2022a: 8). Lindberg et al. (2023) concluded that a GEAF governance structure composed of actors from universities, advocacy groups, and government food regulators would help facilitate public trust and acceptance of GEAF.

Advocacy and alternative agriculture organizations have argued that GEAF poses significant public acceptance challenges due to its association with GMOs, scientific complexity, and social, environmental, and ethical concerns (Helliwell et al. 2019). As this area continues to grow in attention, and if more products arrive on the market, proponents and critics will contend with one another to shape the future of the technology. Thus, early messaging about GEAF represents a transformative symbolic and politicized locus where messages conveyed to the public serve strategic purposes by competing stakeholders. Notably, trust-building priorities may likely serve as evidence that demonstrates to the public that the food technologies, producers, and products are trustworthy or untrustworthy; they are the vehicles that drive trusting relationships, which in turn drive consumer behavior in the marketplace to purchase or avoid products under consideration. Thus, cultivating public trust or distrust in GEAF is a primary objective sought by stakeholders who compete to influence consumer decisions.

The goal of this paper is to document and describe the priorities of key stakeholders vying to influence public trust regarding gene-edited food developments. To do so, we employed a qualitative grounded-theory approach to evaluate interview data collected from 36 proponents and critics representing interests from both the agri-food and biotechnology sectors as well as from advocacy and alternative agriculture organizations. Our inquiry was guided by the following research questions, “How do proponents and critics conceptualize trust-building?” “Do proponents and critics differ in their priorities for building public trust and if so, what are the major distinctions in their priorities?”

We begin with a literature review which frames our investigation and then describe our qualitative research methods. These interview data are then synthesized in the **results** section where we report the first typology of trust-building priorities from prominent organizational actors who actively seek to impact public trust regarding novel food products developed using gene editing. This theoretical development

is further explained in our [discussion](#) section where we identify discordant priorities across and between proponents and critics and present critical insights and opportunities for future research in this area.

Literature review

Public trust of GMOs

Public understanding and perceptions of technoscience are shaped by their judgment of the trustworthiness of key organizational actors including biotech companies and civil society organizations who are positioned to frame social problems while defining potential risks and responses in relation to the technology (Clarke 1999; Devaney 2016; Lang and Hallman 2005; Meghani and Kuzma 2011). Here, we conceptualize trust as an individual's willingness to accept some degree of vulnerability with a relational partner with respect to a particular issue, in this case gene-edited foods (Schilke et al. 2021). Trust in GEAF is tied to the history of GMOs where proponents prioritized trust-building efforts by seeking to improve public acceptance of science and technology. The term "deficit model" was coined in the 1980s by social scientists to describe the underlying assumptions of science communication where the general public's negative attitudes and poor acceptance of science and technology were assumed to be based on subject-matter ignorance (Sturgis and Allum 2004; Wynne 1992). Concerning GMOs, the proposed remedy promoted by proponents was to improve science literacy among the public through one-way communication efforts where scientists communicated known facts about GMO risks and safety to various publics. The dominance of the deficit model resulted in marginalizing many of the non-scientific and non-safety concerns expressed by the public about biotechnology (Jasanoff et al. 2015; Kleinman and Kinchy 2007).

In following decades, the deficit model has been criticized as myopic and misleading, because increased science knowledge does not always correspond with improved trust or public acceptance of technologies (Irwin et al. 2013; Ziman 1991). This resulted in calls to replace the deficit model with alternative approaches that seek to build trust and participation in technological decision-making processes through values-based considerations of diverse publics with distinct concerns (Berube et al. 2010). Nevertheless, the deficit model remains subtly embedded in many public engagement initiatives and trust-building efforts (Ahteesu 2012) and remains a deep-seated assumption held by policymakers and natural scientists who believe that "when controversies over science occur, ignorance is at the root of public opposition" (Bubela et al. 2009, p. 515).

Slovic's (1993) research on nuclear energy showed that negative events more greatly impact trust than positive events. Known as the asymmetry principle, trust is much easier to lose than to gain. This has been observed for GM foods where Poortinga and Pidgeon (2004) found that negative events had a greater impact than positive events on building consumer trust in GM food products and biotechnology companies. Over the history of GMOs development and use there have been many noteworthy negative events that may have contributed to widespread loss of trust in GMOs, including concerns related to potential deleterious effects of GMOs on the environment (Viennese Doctors' Chamber 2013), several high-profile lawsuits involving intellectual property, genetic contamination and farmers rights (Harris 2013), a lack of rigor within regulatory processes (CSAPH 2012), and consolidation of food supply control among GMO producers (Clapp 2018).

Furthermore, many of the promises made by GMO proponents — that GMO products would diminish poverty and hunger, improve sustainability, increase nutritional content, and provide higher quality food — did not materialize during the rise of GM food production through the early 2000s (Lipton 2001; Shiva et al. 2011). Further material faults of GM foods products have challenged public trust dynamics including the trials of products like the NewLeaf potato which was abandoned following low uptake and potential environmental risks (Lyons et al. 1999). The material failures of GM cotton have also caused this non-food GM crop to be completely abandoned in Burkina Faso after farmers found that the quality of the lint to be inferior to their previous native plants causing tens of millions of dollars in revenue lost (Luna and Dowd-Uribe 2020).

Instead, the most significant GM crops were transgenic (insertion of foreign DNA from non-sexually compatible species) herbicide or insecticide tolerant varieties that lowered labor costs for farmers rather than to create any consumer benefits or produce desirable human or environmental health effects (Buttel 2005). These past interactions resulted in a demonstrative loss of particularized trust in GMOs among various members of the public and may also have invigorated antagonistic sentiments among critical groups.

While proponents often sought to improve trust and acceptance through what they deemed rational, science-based communication, GMOs were also fiercely opposed by a variety of individuals, groups, and organizations with distinct belief systems that underscored their concerns (Kuntz 2014). Several advocacy groups opposed GMOs and some research contents that advocacy groups sought to breed distrust among consumers. Many critical groups leveraged early internet communication to create impactful anti-GMO messaging to "refute rationalistic claims about the safety of GMOs" and proliferated a "multiplicity

of diffuse narratives” that brought attention to trust issues and obfuscated understanding of the true-to-life risks presented by GMOs (Clancy and Clancy 2016, p. 279). Some critical groups forwarded claims about GMOs that stemmed from environmentalist priorities urging consumers to distrust GMOs as they were “unnatural” or posed significant health and safety concerns for humans and the environment. Other groups sought to cultivate public mistrust not due to a lack of knowledge or concerns of risk but instead due to insufficient public involvement in decision-making processes enacted by industry and government organizations (Kuntz 2014). ‘Upstream’ public engagement models were demanded by such groups to “make visible the invisible, to expose to public scrutiny the values, visions, and assumptions that usually lie hidden” (Wilsdon and Willis 2004: 24). Others still echoed the social priorities of Glenna and Jussaume (2010, p. 10) who noted that GMO development has taken place within agricultural systems that are economically and socially inequitable and that “a greater focus on social equity may help to break down barriers between GE researchers and sustainable agriculture groups.”

This contentious history shapes what is today a complex milieu of motivations, priorities, and strategies for trust building where organizational actors prioritize distinct elements of GEAF that they feel will best shape how the public comes to trust or distrust its development and use. To better understand these concerns, we seek descriptive answers to our research questions and our culminating typology provides theoretical insights into how key stakeholders actively seek to influence the trust building process which will underscore public trust and ultimately the success or failure of this latest generation of agricultural biotechnology: gene editing in agriculture and food.

Methods

To answer our research questions, we employed qualitative content analysis of semi-structured interview data from a grounded theory perspective. Informants were identified with the aim of selecting a heterogeneous sample to capture the breadth of views and knowledge. Informants were located through web searches for organizations and news stories referencing GEAF. Others appeared in public reports for workgroups and meetings on the topic of gene editing or GMOs. Once interviews began, additional informants were obtained through snowball sampling (Blaikie 2010).

The informants were associated with organizations from the agriculture and biotechnology industries; policy advisory; government regulations; food and supermarket industries; university researchers and associations; legal expertise; non-profit biotechnology research; agricultural commodities; and alternative agriculture. In addition, we interviewed representatives from advocacy organizations whose primary focus included environmental protection; biotechnology and food security; food safety; alternative agriculture; and community development. In total, the data set included 36 interviews from a variety of organizations, with some interviews consisting of more than one informant from the same organization. Approximately 25% of the sample were affiliated with more ‘critical’ advocacy groups. While this may seem lopsided, it is important to note that at the time of the interviews many advocacy and environmental organizations had yet to voice a stance on GEAF. Furthermore, considering product development more generally, there are always likely to be more vested proponents than critics. In addition, some critics declined our interview request following our disclosure that the grant program was funded by the USDA. All activities were conducted following approval through Iowa State University’s Institutional Review Board which reviewed the methods proposed for research to ensure that they are ethical (IRB #18–188), and respondents provided informed consent prior to their involvement in the study.

Interviews were conducted between June 2018 and May 2019. This was shortly after the USDA’s preliminary decision in March 2018 to include gene-edited plants among crops that do not require regulatory oversight (USDA 2018). All interviews were audio-recorded and later transcribed using a quantitative identifier for confidential reporting. We conducted both in-person and telephone interviews, each roughly one hour long. Broadly, interviews were designed to collect data on the informants’ understandings of gene editing in food and agriculture related to risks, benefits, governance, efforts to foster trust among publics, and lessons learned from the GMO debates. Table 1 below reports the organization categories of our informants.

Table 1 Interview informant organizations

Organization Type	Proponent	Critic
1. Advocacy	2	7*
2. Agriculture and biotech industry	10	-
3. Government agencies	3	-
4. Food and supermarket industry	5	-
5. University scientists and associations	2	-
6. Legal experts	1	-
7. Biotech research	1	-
8. Alternative agriculture	-	2
9. Agricultural commodity groups	3	-
Total interviews (38)	27	9

*Among this group 4 represented environmental activism organizations and 3 represented consumer protection and food safety organizations.

Data management and approach to analysis

To build this typology of GEAF trust related issues across organizational actors, we followed the data management and analytical approach pioneered by Halcomb and Davidson (2006). Transcribed audio files were also housed within NVivo for textual analysis. During transcription and post-interview reflection, the researchers reviewed the audio recordings of the interviews as needed to revise trust-related observations. The researchers also sought to identify direct illustrative quotes that exemplify key trust-related themes. This approach helps minimize interviewer biases and improve cross-case comparison of findings. The extracted trust-related information from the interviews was then compiled into a 334-page compendium of direct transcriptions from respondents which were used for the primary analysis in this study.

The lead author employed a grounded theory approach with “the aim being to explore the dimensional range or varied conditions along which the properties of concepts vary” (Strauss and Corbin 1998, p. 73). Using the constant comparative method, each unit of observation (trust-related textual excerpt) was compared against one another to inductively assess potential emergent constructs without *a priori* assumptions of the content or form of those constructs. This inductive analysis design allows for sought-after themes to emerge from patterns present in the cases under analysis without presupposing what the important themes will be (Patton 2015). The concepts identified in our typology reported in the results section were developed through this in vivo coding process that sought to reflect the “vernacularity” of organizational actors’ responses (Given 2008). Following the initial coding of the various priorities identified across the entire sample, we grouped themes by ‘proponent’ or ‘critic’ affiliations which helped to shape the priorities that were cited by each group as well as of shared “contest space” where these groups report discordant views upon similar priorities for influencing public trust.

Results

The answers to our research questions are reported in our resulting typology of GEAF trust issues which is organized across three dimensions including: (1) proponent priorities, (2) critic priorities, and (3) contested space inhabited by incongruent considerations of both groups. The organization of the typology in this way provides greater theoretical insight into how these groups, often portrayed as being diametrically opposed, may vie to influence public trust by prioritizing both unique and overlapping issues. This reveals their unique and shared motivations and values and uncovers a more nuanced understanding of their approaches to cultivating particularized public trust in GEAF. We argue that the identification of priorities unique to each group as well as their overlaps may foster opportunities for improved understanding of public trust building dynamics as this nascent area becomes the focus of greater public attention. The full typology is reported in Table 2 and each dimension is elaborated below.

Proponents

We found that proponents of gene editing, especially large-scale producer-facing biotechnology and seed companies and trade organizations, were engaged in efforts to reflect on and incorporate what lessons they needed to take away from the GMO experience. Reflecting on these lessons was important to “get right” the development and commercialization of gene-edited products and “set the conditions that will allow us to deliver the benefits of the technology” (217). Proponents recognized that the focus on the information deficit model as their major public engagement strategy around GMOs was a failure, and that they need different approaches to building trust in GEAF. This was viewed as critical to ensuring that gene editing did not face the same social resistance that GMOs faced. One proponent explained “the bottom line is we don’t want GMO 2.0 to happen again, right?” (240).

As noted in our typology, the three proponent priorities (avoiding science-talk, cultivating shared values, and increasing transparency) as well as the four contested priorities (framing benefits and risks, defining GEAF, labeling, and delegitimizing the opposition) are all message strategies that mark a direct priority to shift public focus away from their past interactions with GMOs. Their priorities seek to shape information from which the public will base future trust relationships and identify GEAF as distinct from consumers’ previous experiences with GMO. Instead, they focus more readily upon envisioning future benefits of gene editing and gene-edited foods as well as the reputational status of the organizations. These strategies shift focus away

Table 2 Typology of trust building priorities

Proponent Priorities	Contested Spaces	Critic Priorities
Avoiding science-talk	Framing benefits and risks	Decrying corporate control
Focusing on shared values	Defining GEAF	Considering alternative agricultural approaches
Increasing communication transparency	Labeling	Improving regulatory oversight
	Delegitimizing the opposition	

from the epistemic debates which exacerbated previous attempts to improve acceptance of GM foods. In this section we discuss the findings of the three proponent priorities.

Avoiding science-talk

One foundational lesson learned by proponents from GMO development is that social license cannot be built by simply trying to improve the science literacy of consumers. Stemming from this more contemporary understanding, many proponents voiced their support to purposefully avoid science-talk, that is, engaging in discourse focused on the scientific aspects of GEAF with consumers, especially at an early stage of public discourse:

Science at the beginning of the conversation only polarizes the audience. Those who agree with you, agree with you more, and those who disagree, disagree more...if you don't trust me and I explain that I have research that proves that what I'm saying is true, you don't care because you don't trust me... it's hard to see any situation in which the science itself is actually going to change the conversation. It's important, but science follows trust. It doesn't lead it. (213)

Others within the proponent group noted that science-talk may spur negative affective reactions among consumers. When speaking of a specific GEAF producer's messaging, one respondent said, "I think they used the word mutation at some point. "It's not transgenic, it's just a mutation." When you say the word 'mutation,' you've lost everybody. Nobody wants to eat mutated food either. Right? Putting it in scientific language isn't going to help anything" (223). This was similarly echoed by statements regarding consumer sense-making where, "the real fundamental underpinning is that people's ingrained, individual heuristics about how they view food, and the food environment is more impactful than any scientific argument that you can make" (224). In sum, most proponents are keen to avoid the pitfalls of science-talk and instead seek to build trust through other messages.

Focusing on shared values

A prominent theme reported among proponents was a desire to demonstrate shared values between GEAF producers and consumers to build social trust. Values affect individual considerations of ethical intentions and behaviors and are the cornerstone of axiological considerations of what is societally considered right or wrong or what "ought" to be. Collective shared values manifest cultural social systems from which personal values exist in relation to prevailing social norms. Thus, demonstrating shared values between GEAF

proponents and consumers may be a viable way to improve individual public acceptance of GEAF applications and it may augment longstanding factors that drive societal norms regarding food production and consumption.

In our study, proponents sought to establish shared values as an entry-point to encourage consumers to engage in discussion and to not be dismissive of GEAF. As one proponent noted, "We have been focusing our communication strategy on thinking about how to have a better conversation about gene editing. Our focus is on shared values" (217). Others echo the general sentiment that shared values is a priority:

saying that if consumers "understand who you are and the values that motivate you, they generally actually don't care what it is you're doing... My presentations are designed to build trust with the audience before I talk about anything that might be considered controversial, or that they might disagree with. That's important, because if you don't trust somebody, you just don't trust anything they say. But if you trust somebody and they disagree, well that's open for conversation" (213).

This focus on establishing shared values is also thought by proponents to demonstrate that GEAF producers lead similar lives to common members of society which may also increase trust. "I do think our messaging needs to be a lot more concentrated on shared values. We need to start with ...saying 'Look, I feed my kid this food. I love my kids. You love your kids. I wouldn't feed this to them if I didn't think it was safe' ...I think it's important that we begin to establish trust by starting with our shared values" (216).

Several proponents mentioned the Center for Food Integrity (CFI) that began prioritizing the importance of communicating shared values as a means for building public trust, however they did not identify which values should be communicated or how those values ought to be communicated.

Increasing communication transparency

Transparency, defined as the open provision of information regarding matters of public concern, is regarded as an ethical and normative communication practice which can have significant bearing upon public trust in organizations (Lee and Li 2021; Cotterrell 1999). Through our interviews, many proponents noted that engaging with the public in a 'transparent' matter was central to building trust in their organizations and products. Part of their rationale for this is an effort to "get out in front" of any potential criticism of the technology. This contrasts with the debates around GMOs, where proponents did not engage with the public and by the time they did engage, criticisms of GMOs were widespread

and difficult to counter. As one GEAF developer noted, “We have another opportunity for how we approach our communication and our engagement. As we talk with people across the spectrum from regular consumers to retailers... We didn’t really engage [on GMOs] and even when there were engagements it had already been a demonized technology” (237).

However, many proponents were vague about what they intended to be transparent about, but they noted that desires for transparency stem from demands made by consumers to have access to information. One proponent noted that consumers are “used to being able to access whatever information [they] want in every other aspect of [their] life if [they] go to the internet. Why shouldn’t [they] be able to find out what [they] want to about the food that [they’re] eating?” (226) Many proponents equated transparency to companies not using gene editing elusively, and being willing to provide information regarding gene editing processes if the public requested it. As one industry representative noted, “Consumers are demanding transparency, and transparency is this word that keeps coming up. Transparency is foundational to trust. They want to understand what your practices are, how you’re treating the animals, how you’re taking care of the soils if you’re producing crops. What kind of chemicals are you putting on the ground, and what kind of seeds you are using” (223).

However, we found internal disagreement among proponents about the degree to which companies should provide open access to information. There was some caution expressed about not making more information available than was necessary to not “overwhelm” the public: “we’re trying to take a really open-minded approach regarding our willingness to share information because you can just overwhelm people with a bunch of information, and I don’t know if that’s really going to help anybody” (226). Others noted that consumers should be able to access information freely and that, “if you give them most of the information that you have available and be as transparent as possible... largely people will make the right decision. It just can’t look like you’re hiding stuff” (224). Others still note that transparency may hold little value and may only stoke the views of consumers who fervently oppose GEAF: “transparency is a big bullshit word that’s used a lot lately—to be very candid. And so people continue to say ‘I want more transparency’ well I don’t know what that means from you. Does that mean putting studies on a website that you can look at? As soon as I do that, somebody comes out and says, ‘That’s not enough—do this.’ And the goalpost continually moves” (236). While the views regarding transparency are themselves somewhat opaque, for some proponents, transparency, as a messaging strategy, is best actualized through

physical food product labeling as is further discussed in the contested spaces subheading below.

Critics

Critics represented advocacy and alternative agriculture organizations. Like proponents, critics independently focus on unique priorities they believe must be met for GEAF technologies to be publicly trusted, however, at times, they also actively seek for the public to distrust GEAF and dissuade consumers from trusting in food and biotechnology developers. As observed in the typology, this group prioritizes legacy concerns and desires to shape public trust through consumers’ previous experiences and their perceived ‘unresolved’ issues related to GMOs. They also seek to shape potential risks of GEAF and shift public focus to alternative agricultural processes while also condemning many of the actions and inactions of industry and government regarding GEAF practices.

Decrying corporate control

Many critics reported that one fundamental problem is that gene editing is being developed mainly by large corporations to increase profit margins where “the technology will be exploited for profit, and the profits are controlled by companies that don’t have good motives. Therefore, however it’s developed isn’t relative to however it gets used” (234). This consideration was echoed as others maintained that CRISPR applications themselves would be limited within commodity agriculture where it would be unlikely to lead to substantive changes: “Whoever ends up winning [the patent battle] is going to maintain a huge amount of control” (233). Many critics believe it is unrealistic that CRISPR technologies will usher in an era in which a variety of small and mid-size companies, public scientists, and research institutes can create novel GEAF products. As one critic noted, “the technology itself may be more accessible, but the commercial development of it is not” (234). Among this group, wide equity concerns were expressed that development and use of GEAF will consolidate power among current industry leaders, where “genetic engineering [may] concentrate more power in the hands of very few corporations which currently control our food system” (204).

Considering alternative agricultural approaches

Critics also questioned if GEAF and other biotechnologies are the best option for solving agricultural problems and sought to increase public awareness about alternative agricultural approaches. They viewed proponents of GEAF as shortsighted and overly reliant on technology for problem

solving rather than seeking out other alternative solutions, noting, “we’re way out of balance in terms of diversity of approaches that will be fairly funded and treated equally” (232). Another critic said:

You have a whole generation of farmers that now believe the only way you can effectively deal with a weed is to buy a package of seed and herbicide that work together... We’ve been working very intensely with [USDA] NIFA making the argument that they are one of the most important sources of funding that determines the research agenda for public scientists, and that they should set aside money for alternatives that don’t make farmers dependent on the biotech approach. (217)

The motives of large companies were also under criticism for cultivating a business model that does not allow for consideration of alternative solutions. According to critics this business model also discredits alternative and traditional forms of plant breeding, such that large corporations have “essentially dismantled and defunded the vast majority of foods we eat around the planet today developed through classical plant breeding, which is a very sound, broad-based approach that is not shown to have any ill effects... At the same time, we’ve undermined this system that has brought us all to where we are today in terms of the diversity of agriculture” (232).

Improving regulatory oversight

Many critics also voiced that public trust would be improved through increased regulatory oversight of GEAF processes and applications. Critics’ desires for increased regulations stem from historical mistrust in industry representatives to account for product-related risks where “We need to have oversight and regulations, so we don’t have the current situation, which is companies that are self-proclaiming their products as safe... History has taught us time and time again that we can’t trust a company to do its own safety assessments” (204). Furthermore, critics call for multiple forms of safety testing and evaluation of ancillary effects of GEAF. One critic noted, “We don’t hear about the fact that we’re poisoning our environment, air, water, eroding the soil, displacing farmers.... we need more complex evaluations, and the regulatory mechanism should tend to that. That means there should be a strong public sector component, there should be strong public health component, a strong environmental component” (217).

Critics also voiced their concerns about a “rush to market” of GEAF products and advocated for more conservative and precautionary approaches to market gatekeeping

noting, “All genetic engineering techniques, including gene editing, should fall within the scope of government regulatory oversight of genetic engineering and GMOs, and we need to follow the precautionary principle given how little we actually understand about genetics, the unintended consequences, and the impacts on the health of the environment” (204). Other critics voiced that public trust has deteriorated due to policy changes under the Trump administration of the United States which was described as “openly hostile to regulating anything. Biotech just can walk right in and not be regulated because everybody can walk right in and not be regulated. The last administration didn’t want to regulate it either” (210).

Contested space

This contested space of the typology identifies areas where proponents and critics both voiced significant priorities for public trust building regarding GEAF, however in each of these areas the groups vie to frame GEAF issues in distinct and discordant ways. We describe how each group — proponents and critics — voiced their priorities related to framing benefits and risks associated with GEAF, defining the field of GEAF itself, and their views on mandatory and voluntary labeling of GEAF products in the commercial marketplace.

Framing benefits and risks

There is little surprise that proponents more readily prioritized envisioning benefits of GEAF while critics maintained a strong focus on potential risks of GEAF processes and products. Proponents voiced that consumers would be more trusting if they could see tangible benefits of gene edited products. “There needs to be very clear benefits that people recognize, that would be in contrast to the GMOs where benefits went primarily to farmers and companies that sold seeds to the farmers. If there were real consumer benefits, real bona fide health benefits, I think that can help” (228). Specific products brought up by proponents included non-browning apples and “better tasting tomatoes” that may be viewed more positively by consumers (216). Proponents also thought that potential environmental benefits would garner wider trust among consumers. While proponents did not identify any specific applications, they made mentions regarding the benefits of previous GMO products and compared them to potential GEAF applications under development noting that “we in the agriculture community never did a good job addressing the link [between GMO and] sustainability. With gene editing, if it is indeed a product that helps improve sustainability, we also can tell that story and get out in front in terms of talking about how it’s not just helping the farmer; it’s improving the environment” (216).

Critics reported greater concern for potential risks of GEAF applications and noted that the public should be mistrustful of industry claims regarding environmental benefits, as well as be highly skeptical that gene editing would deliver wide benefits. Coupled with desires for more precautionary governance approaches, critics noted that major risks would come from “the unintended consequences of the gene editing” (234). Critics also noted that the public should be concerned about the scientific process of gene editing and that by editing for specific desirable traits, scientists may inadvertently cause a species to become more prone to disease or inhibit environmental factors that “maybe spreads to wild vegetation and wipes it out” (234). One advocacy group representative also voiced that the public should be privy to risks posed to organic farming where “the trespass from pollen or other transfer of genetically altered foods can contaminate organic foods very easily. And that’s a huge threat. And it makes no difference if its gene-edited or regular GMOs other than you can’t always test for gene-edited at this point” (234).

Defining GEAF

The definition of gene editing in agriculture and food itself is contested as proponents and critics hold distinct priorities for how it ought to be defined which has significant bearing upon how the public will come to understand GEAF. Proponents seek to distance gene editing from genetic modification and equate it with improved processes of ‘traditional plant breeding,’ where gene editing “is just a more sophisticated way of doing what we had been doing for centuries. We used to do selective breeding in a much cruder way. This is a much less crude way but otherwise it has just sped up selective breeding” (201). This prioritization seeks to further distance the public from basing trust decisions on previous experiences with GMOs.

As a counterpoint, critics note that gene-edited foods are genetically engineered and seek to define GEAF as essentially GMOs. One consumer advocacy group representative noted: “For our organization, gene editing is genetic engineering. The genes are being modified, which is what a GMO is, and we need to call that what it is. So, when people talk about gene editing as something different from GMOs or try to not talk about it in the light of genetic engineering, that is deceiving” (204). Others critiqued the idea that gene editing is like traditional plant breeding and one critic went as far as to say they “should be defined differently. It should stand out there, anything biotech, where we have gone in and manually reached into the genome. That’s biotechnology... And the consumer ought to be able to understand that this is something where we used technology, essentially to create this food that you’re eating versus selective breeding”

(201). Critics’ angst over the definition of gene-edited crops as selective plant breeding was not targeted just at industry producers, but also at regulatory agencies which may demonstrate some of the continued distrust in government to act as third-party arbiters. As one critic noted, “it is disingenuous for USDA to have made the decision that they have made, that genetic engineering is essentially equivalent to selective breeding. It needs another look... we will get in trouble because we have decided we are not looking” (201).

Labeling

Product labels, like those proposed for gene editing, serve a heuristic function among consumers that provide comprehension cues in low information contexts (Cummings 2017). In our interviews, all critics advocated for labeling of gene-edited food products, but only some proponents voiced similar support—and the motivation and message contents for labels come from divergent perspectives between the groups which would significantly alter how the public comes to identify and trust gene-edited products as trust objects.

Critics voiced concerns that follow from their beliefs that GEAF should be classified similarly to GMOs where:

all products and ingredients of genetic engineering, including gene editing like CRISPR, needs to be clearly labeled... it's really unclear whether the current proposal at the federal level for labeling would include new genetic engineering techniques like CRISPR or gene-edited crops, or not even gene editing. For example, if something is produced from genetically engineered wheat, or like the heme from the impossible burger, or fry oil, which is an oil produced from genetically engineered algae. Those all are genetic engineering, and those all need to be labeled. (204)

Proponents who supported labeling view it as an opportunity to increase transparency for consumers and build trust by providing cues that improve consumer comprehension of products. However, many proponents are also concerned that labeling may serve as a warning symbol highlighting potential hazards which may delegitimize safety evidence among consumers and equate a GEAF label as a “do not buy” caution. This trade-off is manifest in two camps, with the proponent group where some support labeling to increase transparency while others note that the label is not in the public’s best interest and would likely erode trust: “Yes, absolutely [we are for mandatory labeling] ... If [products] are not [labeled] it just invites more criticism that we are not speaking to what is “in people’s food”, so whether or

not it is scientifically valid or not, I do think it is important that we completely eliminate that argument, that we're hiding something. We're not. We're absolutely not" (224). As a counterpoint voiced by another GEAF company representative, "Gene-edited food is a very different application than GMO, so it should not be lumped together. [Labeling] is the strategy of anti-GMO groups who want to keep the GMO debate going" (230).

Some proponents also voiced their dissatisfaction with the non-GMO verified labels noting:

People in this country are unwilling to take much risk because they can afford to avoid any risk, even if it's a perceived risk and there's no real risk behind particular food products... that's what we've seen with non-GMO salt, non-GMO water, non-GMO oregano. Clearly there are no GMO equivalent of these things, but people are willing to pay more because there's a perceived risk. It's illogical... but people are buying this label even though it doesn't mean anything (230).

The sentiment that the current allowance and illogical use of non-GMO labeling was shared among some critics as well where one civic advocacy group representative said, "I'd rather they had to pull off all the non-GMO labels on things that couldn't ever be GMO. It just makes me crazy" (201).

Delegitimizing the opposition

A minority of both proponents and critics also divulged that they must ready their organizations to combat the concerns and communication of the other group to effectively shape public trust in their desired direction. They recognize that both proponents and critics are vying to shape the information climate related to gene editing and one anticipated action is to delegitimize the perceived opposition and influence the reputational status of the other.

Some proponents demonstrated concerns about the motives of advocacy groups noting that "All activists are either ideologically or commercially driven" (237), and:

there's a number of groups that have a big interest around essentially aggregating [GEAF] and lumping it around GMO 2.0. If they're making money and their business model and their livelihood is dependent upon there being a GMO controversy, then as the technology moves on and they want to continue and be successful in their activism and business model- their donations or whatever it is- they've got to keep the GMO controversy alive and well. So, it's in their best interest to continue to lump things as GMO whether they are or not. (233)

Beyond speculation of critics' motives, some proponents anticipate push-back from critics. Said one proponent:

we're very closely tracking coverage out there, in social media and the news, and we're happy that it's mostly neutral to positive. There's not a lot of negative out there yet, but we know those activist groups are going to spin this. And we've already seen a little bit of that. ...I think one of those taglines some of those activists are using is 'GMO 2.0'. That's one of the biggest challenges. (239)

Other proponents also reported their dissatisfaction with the veiled arguments of advocacy groups during the GMO era which sought to stoke fears among consumers of technological risks in lieu of discussion of other socio-technical considerations:

Don't trot out false health, safety, environmental concerns that are really proxies for discussion of law, regulation, policy... it's misinformation, it's lying to the public. If you've got legitimate concerns about market power, about control, about regulation, then let's have that discussion but don't go out and scare the public with falsehoods... Let's be honest with the public and the consumers in that, because that's where GMOs went in the ditch... Don't try to scare the public about something that's not the point. (225)

Critics similarly noted that proponents are often veiled and disingenuous in their communication. Said one critic of GEAF developers, "If you really do have legitimate ends to help people, then pursue those ends without making a fetish of a particular technology to get there" (220). They went further to note the entrenched and warring views where critics must be spendthrift in their efforts to combat a significantly larger foe, where "compared to the forces that are trying to sell this technology to us, it's like David versus Goliath. We have limited resources and so we focus a lot on what I call 'real world biotechnology'. The stuff that's actually cutting edge and at the approval or commercialization stage and having real world impacts... and that takes up a lot of time. It's hard to try to fully engage something that's still mostly on the horizon" (220). This pointed argument reveals deep-seated distrust between the organizational actors who each believe the other party to use manipulative tactics to sway public trust.

Discussion

Proponents and critics of GEAF in the U.S. provide early and foundational messaging which contribute heavily to public trust, salience, and decision-making as potential consumers reflect upon their experiences, envision future outcomes, and consider the reputation of those trying to influence them. As others have noted from large-scale quantitative surveys, most members of the public are not actively seeking information on GEAF and that most members of the public do not intrinsically favor or oppose genetic modification or gene editing (Hanssen et al. 2018). As is documented in our results, the trust-building priorities of these groups often stand in opposition to one another and are influenced by distinct motivations for how the public will come to trust or distrust GEAF actors and objects as more products are developed and enter the market (Cummings 2017; Cummings and Peters 2022b). Our typology demonstrates that proponents are actively prioritizing new ways to build trust among consumers that are distinct from previous generations of agricultural biotechnology development while the trust-building priorities of critics are largely a continuation of legacy concerns raised in previous decades regarding GMO crops.

Furthermore, our typology illustrates broad acceptance among proponents that public trust in GEAF will likely be informed by factors that extend beyond technical risks and benefits (NASEM 2016). This stance is corroborated by recent public opinion data. For instance, Cummings and Peters (2022a) demonstrated that while there is considerable uncertainty about the degree to which the public will accept or reject GEAF in the U.S., they found clear indication that deep-seated, antecedent core values regarding food beliefs, science and technology, institutional trust, and awareness of gene edited foods drove individual's willingness to eat, or purposeful avoidance of gene-edited foods. Busch et al. (2022) also found survey participants in a comparative study including Canada, the US, Austria, Germany and Italy reported that attitudes about gene-edited applications were based on both reasoning and gut feeling and that a 'natural-is-better' heuristic "seems to influence perceptions" of gene editing applications. Noting these findings, it makes sense that rather than overtly seeking to overcome the information deficit model, proponents now report actively seeking to avoid science-talk and instead seek to build public trust by focusing on priorities like increasing shared values and transparency of their development practices. In this way, proponents may seek to influence the public's reputational belief of themselves and their products to cultivate a greater sense of trustworthiness.

Contrary to the novel priorities of proponents, critics voiced that legacy concerns about biotechnology-enabled

agriculture persist for GEAF developments, and those concerns could help foster a sense of public distrust about food and biotechnology developers and in gene-editing processes and products as trust objects. While some critics noted that they believe GEAF could garner benefits for some members of society, they feel that the public would be more trusting of such technologies if there were significant improvements made to other related issues within the larger constellation of agricultural development, namely limiting corporate control over GEAF use, considering alternative agricultural approaches, and improving regulatory oversight. Critics note that these issues have yet to be addressed to a standard they feel would readily build trust among the public. This resonates with recent work of Will et al. (2022) who found widespread distrust among civil society organizations in the European Union about seed and plant breeding companies.

These concerns are echoed in recent regulatory changes regarding how, and when, biotechnology-enabled food products will be labeled. Beginning January 1, 2022, all transgenic GM foods in the United States have been mandated to comply with the new National Bioengineered Foods Disclosure Law and Standards and host a label using the term "bioengineered," however, as many gene-edited foods are cisgenic, they do not fall under this new regulation and will likely enter the commercial marketplace unlabeled (Jaffe and Kuzma 2021; Selfa et al. 2021). Many of the critics in this study who conflate GMO and GEAF technologies feel that all such products should be labelled and that such division of standards may lead to wider distrust among the public. This is distinct from some proponents we interviewed who feel that GMO and GEAF should be distanced conceptually from one another and note that labeling GEAF may delegitimize products and serve as a "do not buy" caution which would damage public trust. Our work supports assertions from Kofler et al. (2018) who argued that many developers seek to build trust "[i]n the absence of widely agreed-upon governance guidelines or support for more optimal deliberative processes" (527), and in this climate, GEAF developers often serve as the primary sources of risk and safety information. In such an asymmetric information climate, gene editing proponents enter an "advice-and-consent relationship" which may constitute a conflict of interest. Poort et al. (2022), Kofler et al. (2018), as well as many critics within our study, argue for increased plans to incorporate "perspectives that are independent, transparent, inclusive, and based on balanced deliberations" (527).

While we argue that this typology provides robust and granular understanding of the priorities of proponents and critics as they vie to influence public trust, we would be remiss if we did not identify potential limitations of this study. First, our data analytic approach to the interviews employed *a priori* identification of 'proponent' and 'critic'

groupings—thus, our results engender themes across these nominal identifiers which both enables group comparison but may also influence our analytic inductive process and final organization of our typology (Patton 2015). Second, 75% of the stakeholder sample were proponents of GEAF, and thus voices critical of GEAF are underrepresented in this study such that additional critical themes may not have been captured through this inquiry.

As is noted by our typology, proponents focus heavily on the messages for the public, avoiding prior experience with food and biotechnology developers from the GMO era as a prioritized form of information and instead seek reputational messaging and envisioning future benefits. Critics however seek to prioritize needs for more stringent regulations that ensure that GEAF will not further consolidate capital among few powerful elites while displacing other agricultural practices and creating social and physical risks for people and the environment. Each group acknowledges their respective views are somewhat entrenched and note they are in competition with one another to shape how GEAF will come to be trusted or distrusted by consumers. As products continue to develop and this debate gains prominence among members of the public, we anticipate seeing the effects of these trust building priorities which may have direct and significant impact on public trust in these key stakeholders, and ultimately the acceptance of rejection of gene-edited processes and products. This research represents an initial step towards identifying the key priorities for building public trust in relation to GEAF among various stakeholder groups. However, further investigation is necessary to fully comprehend the subtle distinctions between different product developers and stakeholders at each stage of the food production process, from laboratory to farm to table. To this end, we recommend that future large-scale quantitative surveys and empirical evaluations of public communication strategies be undertaken to more thoroughly examine the claims made by different organizations in this field. As new GEAF products are introduced to the market, we anticipate that the priorities for building public trust will evolve, potentially becoming more contentious as various groups vie to shape public perception of GEAF.

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Declarations

Competing interests We have no competing interests to disclose.

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