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# How do consumers perceive open-source seed licenses? Exploring a new credence attribute

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## Abstract

Critical consumerism is the conscious choice of purchasing or avoiding products for ethical or environmental reasons. As an increasing share of consumer attempts to purchase sustainably produced food, credence attributes, which are product qualities that are not easily observable or verifiable during purchase or consumption, gain importance. Variety ownership has so far not played any role in food consumption choices but is a new type of credence attribute that may gain relevance through the recent introduction of open-source seed licenses. Such licenses aim to safeguard agrobiodiversity, ensure long-term access to plant genetic resources and counter current privatization trends in the seed industry. The labeling of open-source produce could help to upscale the concept and enable consumers to support the safeguarding of biodiversity through their consumption choices. However, as the first open-source varieties become available for purchase, consumers' perspectives on open-source seed licenses remain unclear. In this paper, we, hence, examine German consumers' perceptions of open-source seed licenses. The analysis of 228 thinking-aloud protocols, based on qualitative data collected in a conventional and an organic supermarket in Berlin, Germany, serves as an empirical basis. We find that most consumers have a highly positive evaluation of open-source seed licenses, regardless of whether they fully understand the concept or not. The license is widely perceived to provide a counter-model to current industrial seed- and agricultural production. Specifically, it is believed to (1) prevent the privatization of plant genetic resources, (2) contribute to the conservation and enhancement of agrobiodiversity, (3) support (small-scale) farmers and (4) prevent market concentration. To what extent these perceptions coincide with personal preferences for taste, health, safety and quality remains to be explored. The concept may specifically cater to certain consumer segments, including highly educated, young to middle-aged, organically minded consumers.

## KEYWORDS

agrobiodiversity, credence attributes, critical consumerism, food, open source, seeds, sustainability, sustainable consumption, thinking aloud protocols

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## 1 | INTRODUCTION

In recent years, an increasing share of consumers in Western countries engage in critical consumerism – the deliberate avoidance or purchase of products for political, ethical or environmental reasons (Yates, 2011). As an act of critical consumerism, consumers can exercise steering power through their buying decisions, and thereby influence market practices and production patterns (Copeland & Boulianne, 2022). Critical consumers are hence individuals that align their purchasing decisions with collective and/or private ecological, ethical or political values. Their consumption is influenced by complex motivational factors that can lead to ‘foregoing personal gains in favour of a more abstract, somewhat intangible gain to someone or something else’ (Sachdeva et al., 2015, p. 60), for example, through the purchase of more expensive sustainably produced products. Consumers may generally engage in two forms of action: boycotting unsustainable products and services by not purchasing them or, on the contrary, ‘buycotting’ sustainable products and services through their deliberate purchase (Stolle & Micheletti, 2013; Yates, 2011). These actions can either be carried out individually as lifestyle politics or as contentious politics by participating in collective action, for example, organized boycotts (Gotlieb & Cheema, 2017).

In the context of food consumption, sustainability-related product qualities on whose basis critical consumerism is performed are usually credence attributes. Credence attributes are product qualities related to consumer concerns ‘with many parts of the food system: How the food was produced, processed and handled, and how this may have affected people, animals and nature along the way’ (Torjusen et al., 2001, p. 215). In contrast to search attributes (e.g. price) or experience attributes (e.g. appearance or taste), credence attributes are not easily observable or verifiable during purchase or consumption (Darby & Karni, 1973; Fernqvist & Ekelung, 2014). Organic and local production, fair trade and animal welfare are among the most prominent sustainability-related credence attributes, usually made transparent through the use of labels and certification schemes. Plant variety ownership has so far not played any role in consumption choices but presents itself as a new credence attribute that may gain relevance due to the recent introduction of open-source seed licenses. To contextualize our research on consumer perspectives of open-source seed licenses, the rationale and development of these licenses are outlined in the following.

The preservation and further development of a diverse pool of plant genetic resources is a prerequisite for resilient agricultural systems (Altieri & Nicholls, 2017; Altieri et al., 2015). Yet, current developments in the global seed industry raise social and environmental sustainability concerns. Seed production in the Global North has been subject to increasing privatization and is now a lucrative economic activity based on intellectual property rights such as patents and exclusive seed multiplication rights (Clancy & Moschini, 2017). Varieties are thus increasingly under private ownership of a small number of agribusinesses, with currently only three

companies sharing more than 60 percent of the formal global seed market (Moldenhauer & Hirtz, 2017). This has led to concerns related to power imbalances and a lack of democratic participation (Bonny, 2017; Howard, 2015, 2016). Environmental concerns have also been raised since these companies typically focus on a few, genetically uniform varieties that depend on complementary agrochemicals. This narrow focus is aligned with agricultural systems based on intensive farming practices that have failed to deliver positive social and environmental outcomes (Rasmussen et al., 2018). In this context, specifically, the decline of agrobiodiversity and the genetic erosion of plant varieties have been identified as major threats to agricultural production and long-term food security (Kahane et al., 2013; Mijatović et al., 2013).

To counter these trends and ensure access to plant genetic resources for current and future generations, several initiatives have drawn upon open-source principles from the software industry to develop pledges and licenses that inhibit the privatization of seeds and varieties. These initiatives aim to (1) promote diverse, locally adapted varieties, especially for organic agriculture, (2) restore crop seeds as common goods and (3) combat market concentration in the seed industry (Kloppenburg, 2014). The first of its kind, the US-based Open Source Seed Initiative, was formed in 2012 and pioneered a pledge that is now applied to more than 500 varieties. Similar initiatives have since formed in Germany, Argentina, Kenya, Tanzania, Uganda, and India (Moeller & Pedersen, 2018). The contribution of these initiatives to facilitate access to crop genetic resources has been analysed and documented extensively (Kloppenburg, 2010, 2014; Kotschi & Horneburg, 2018; Louwaars, 2019; Luby & Goldman, 2016; Luby et al., 2016; Montenegro de Wit, 2017; Tsioumani et al., 2016; van Zwanenberg et al., 2018).

Consumer perspectives on such licenses have so far not been explored. However, as the first open-source varieties find their way into supermarkets and farmers markets, questions arise as to how consumers perceive open-source seed licenses and which role they might play in the context of critical consumerism. Examining open-source seed license from a consumer research perspective is hence valuable for several reasons: (1) Given the novelty of the concept and the current lack of its widespread adoption it is unclear how consumers perceive open-source seed licenses and how they evaluate the concept. Yet, open source as a potential credence attribute has so far not been explored. (2) Given the crucial role consumers play in generating demand for open-source produce, consumer research on open-source seed licenses can help to determine the usefulness of introducing an open-source labelling scheme for food products as has recently been proposed by Kotschi and Doobe (2020). (3) The transferability of the open-source concept to the context of food products has not yet been explored from a consumer perspective. Research on open-source software, the original field of application, rarely includes consumer perspectives and foremost focuses on participation and community aspects. With a shift in the application of open-source concepts from the virtual sphere (software) to tangible material objects (food products), consumer perspectives on

open-source concepts gain a new dimension that is particularly interesting to explore.

In this paper, we, hence, empirically explore consumers' perceptions of open-source seed licenses through a qualitative analysis of 228 thinking aloud protocols (TAPs), which we collected in a conventional and an organic supermarket in Berlin, Germany. Specifically, we aim to shed light on the following research questions: (1) which social and ecological sustainability challenges connected to seed production and breeding are consumers aware of? (2) how do consumers perceive open-source seed licenses and what properties do they attribute to them? (3) how do consumers evaluate open-source seed licenses? Based on our findings, we discuss the potential introduction of an open-source label and place the findings in the context of critical consumerism research. Our research thereby provides a consumer-centred perspective on the role of open-source seed licenses in the socio-ecological transformation of the agricultural sector.

We suspect open-source produce to be of interest to German consumers for three main reasons. (1) There is a growing interest among European consumers to preserve diversity in the food system, although there is often limited knowledge on how to do so (Oehen et al., 2020). As biodiversity protection gains in relevance in public discourses, its focus remains on habitat loss of iconic species and the insect die-off ('Insektensterben'), with plant and crop diversity often being neglected. However, because declining crop diversity limits the diversity of available produce and therewith consumer choices, agrobiodiversity loss directly impacts consumers. The introduction of open-source produce that is labelled as such would give consumers an option to choose produce that contributes to the cultivation of crop diversity. (2) The merging of the German pharmaceutical company Bayer with the US-American agribusiness Monsanto in 2018 made Bayer the single largest supplier of seeds and crop protection chemicals worldwide, which drew public attention to the seed industry. Within 5 days, the German online petition site compact collected more than 155.000 signatures against the merger and an additional half a million signatures against Monsanto products, indicating strong public opposition to large-scale agricultural companies and their practices. Open-source produce may thus attract the interest of consumers that have a high level of mistrust in agribusiness. (3) Many German consumers strongly oppose genetically modified (GM) organisms, especially if they are included in food products (Bieberstein et al., 2013; Wuepper et al., 2019). If open-source produce is believed to be free of genetic modification, consumers rejecting GM varieties might favour open-source produce. There are thus several reasons to assume that open-source produce is of interest to German consumers engaging in critical consumerism.

We first review relevant literature on critical consumerism (Section 2). Next, we outline the research design and methods for data collection and analysis (Section 3). We subsequently present the results of the analysis (Section 4). The discussion section places the findings in context and reflects on the limitations of the research approach (Section 5). We conclude by outlining the implications and identifying future research directions (Section 6).

## 2 | LITERATURE REVIEW

### 2.1 | Critical consumerism research

The discourse on critical consumerism is a subsection of the broader public policy discourse on sustainable consumption, which includes consumption aspects besides the purchase of products and services, such as product use or product disposal (Peattie & Collins, 2009). We follow Gjerris et al. (2016) and consider critical consumerism to be synonymous with political and ethical consumerism. Critical consumerism has scientifically been explored from various socio-political, economic and psychological perspectives (Copeland & Boulianne, 2022). Food products have thereby been a major subject of interest and are at the centre of the scientific debate on political consumerism (e.g. Saraiva et al., 2021; Sebastiani et al., 2013; Zander & Hamm, 2010).

Although many consumers view themselves as critical consumers, factors such as high price premiums, habitual behavior, or the prioritization of product quality often overshadow sustainability concerns (e.g. Horne, 2009). A strand of social psychological research, hence, investigates the barriers and enablers of critical consumerism, highlighting that although many consumers support critical consumption in general, this does often not translate into actual behavior, resulting in attitude-behavior gaps (e.g. Carrington et al., 2014; Kollmuss & Agyeman, 2002; Olson, 2013; Sharma, 2021). Given the complex factors influencing critical consumerism, Sachdeva et al. (2015) point to the interplay of *endogenous factors* such as attitudes, beliefs and perceptions, with *exogenous factors* such as social norms, peer-to-peer influences and cultural acceptability, and *structural factors* such as product availability, incentive structures and decision nudges. To engage in critical consumerism, consumers need to understand and evaluate the politics behind the product, have the resources to purchase the product, and be motivated to do so (Micheletti, 2003). Consumer perceptions of and beliefs about credence attributes are major influencing factors for (critical) purchase decisions, which can explain up to 75 percent of the variance in decision making (Moser, 2016). With no previous consumer research on open-source seed licenses available, we focus on *endogenous factors* by examining consumers' perceptions of open-source seed licenses.

Critical consumerism cannot be understood as a society-wide phenomenon but is predominantly observed among certain consumer groups. A recent meta-analysis by Copeland and Boulianne (2022) shows that consumers engaging in critical consumerism tend to be highly educated, more often women than men, most likely middle-aged, and have a low level of political trust (also see Stolle et al., 2005; Yates, 2011). It can, thus, be speculated that these consumer groups are particularly interested in open-source produce.

### 2.2 | Labeling

Sustainability-related food labels (sometimes referred to as eco-labels) have played a crucial role in fostering critical consumerism

since they can help consumers to make informed choices and evaluate product qualities using heuristics. They also reduce information asymmetries between producers and consumers, may foster consumer trust and empower consumers to 'express their individual value perception of product characteristics, including the credence quality attributes' (Asioli et al., 2020, p. 5). By reducing information complexities, they provide guiding narratives or storylines that stand for certain production processes and cater to specific lifestyles (Asioli et al., 2020; Gall & Wörner, 2012). Research shows that consumers value the information provided by labels, although they often have a limited understanding of what different labels stand for (Annunziata et al., 2019). Labels with simple and clear messages are typically favoured over vague and complex labels, whose direct benefit for consumers is not immediately apparent (Delmas et al., 2013). However, on the example of animal welfare labels, Weinrich and Spiller (2016) show that German consumers prefer multi-level labels that combine different production and quality standards over binary labels that only consider one dimension. Asioli et al. (2020) interpret this as consumers being torn between a desire for simplicity and clarity on the one hand and a valuation for the availability of in-depth information on the other hand. Furthermore, the credibility and authenticity of food labels play a critical role in fostering trust and are important determinators of the success of food labels (e.g. Lazaroiu et al., 2019; Ricci et al., 2018). However, too many competing labels may lead to confusion and undermine consumers' trust in certification systems.

Sustainability labeling in the food sector is increasingly used as a marketing strategy to support small producers, niche markets, and new market segments. As such, labels can create fruitful tensions to change regulatory frameworks, shape public debates, raise awareness and influence the food- and agricultural sector more broadly (Clarke, 2008; Boström & Klintman, 2008; Klintman & Boström, 2012). However, the tendency of neoliberal policies to place responsibility on consumers to drive market shifts with their spending power is discussed critically in consumer research, as it enables policymakers to shuffle out of their responsibility (Eckhardt & Dobscha, 2019; Giesler & Veresiu, 2014; Mesiranta et al., 2021). Consumer responsibility has become a central element of current sustainability governance that turns state responsibility into individual responsibility and thereby implies that we can 'consume our way out of environmental problems' (Soneryd & Ugglå, 2015, p. 14). Underlying such shifts towards 'conscious capitalism' is the assumption that consumers are interested in and want to act responsibly (Eckhardt & Dobscha, 2019). Yet, ignorance or indifference to the cause at stake, structural and resource constraints, moral dilemmas, information overloads and feelings of guilt and concern can place a burden on consumers and/or lead to resistance (Horne, 2009; Soneryd & Ugglå, 2015). Sustainability-related food labels are hence no silver bullet for addressing unsustainable consumption and should not be used to merely responsabilize consumers. Yet, they are a valuable tool that enable critical consumers to exercise their steering power and can be seen as one of many strategies to shift towards more sustainable consumption patterns.

## 2.3 | Sustainability-related credence attributes

Research on sustainability-related credence attributes in Germany has so far focused on consumers' perceptions and valuation of organic and local production (e.g. Ankamah-Yeboah et al., 2019; Hempel & Hamm, 2016a, 2016b; Janssen & Hamm, 2012; Otter et al., 2018; Maesano et al., 2020), fair trade (e.g. Andorfer & Liebe, 2015), animal welfare (e.g. Yeh & Hartmann, 2021) and carbon- and water footprints (e.g. Emberger-Klein & Menrad, 2018; Feucht & Zander, 2018). Studies related to seed production and breeding are limited to the perceived risks and benefits of genetic engineering (e.g. Butkowski et al., 2017; Christoph et al., 2008; Delwaide et al., 2015; Emberger-Klein et al., 2016; Nielsen, 2013; Wuepper et al., 2019).

The public acceptance of GM food in Germany is relatively low because the technology is regarded as risky for the environment and the society, morally unacceptable, or of limited use in general (Emberger-Klein et al., 2016). The perceived risk of genetic engineering tends to be higher in the context of food products than in the context of bioenergy (Butkowski et al., 2017; Christoph et al., 2008). This is mostly driven by a high concern of personal health impacts from GM food, although environmental consequences are perceived to pose greater risks than health-, socioeconomic- or ethical consequences (Butkowski et al., 2017).

Open source as a credence attribute has so far not been examined in the context of food. Consumer research in the context of information technology, the original field of application for open-source licenses, has primarily focused on user experiences and the perception of users and developers (e.g. Gwebu & Wang, 2010; Lundell et al., 2011; Racero et al., 2020; Raza et al., 2012). Personal innovativeness in technology, social identification with the open-source software community and perceived ease of use of the software have thereby been found to positively influence perceptions of open-source software (Gwebu & Wang, 2011).

## 3 | RESEARCH APPROACH

### 3.1 | Thinking aloud protocols

Drawing on a realist research paradigm, we aim to capture individual realities and perceptions by primarily applying qualitative research methods in the form of TAPs and a supplementary standardized questionnaire.

TAPs are an exploratory method to examine consumers' reactions to a stimulus such as a product, flyer or web site. Participants are asked to verbalize their thoughts and associations while carrying out a stimulus-related task, for example, using a product or reading over a flyer (Ericsson & Simon, 1993; Willis, 2005). Derived from information processing theory, it is assumed that thinking aloud leads to concurrent insights into participants' thought processes (Someren et al., 1994). As new information enters the working memory it is consciously processed and, thus, accessible for verbal retrieval. Nevertheless, environmental and individual factors such as the

cognitive load, the complexity of the stimuli, or the meaning of the information to the individual influence the extent to which cognitive processing occurs (Engle, 2018).

TAPs are well suited to examine how consumers perceive and evaluate products or advertising efforts and have previously been used at the point of sale (Büttner, 2009; Risius et al., 2017; Zervas & Zimmermann, 2004). In this study, we used flyers on the open-source seed license as stimuli. There are two reasons for this: Firstly, consumers are likely to be completely unfamiliar with the concept. Providing basic information is, thus, a necessity to elicit more than blind guesses. Secondly, the use of different flyer versions allowed us to test the effect of various rationales for the license. Flyers as stimuli for TAPs have previously been used to evaluate consumers' perceptions of agrobiodiversity (Bantle, 2015; Bantle & Hamm, 2014a, 2014b) and endangered livestock breeds (Menger & Hamm, 2021). The use of flyers opens the possibility that participants merely recite the information they have read. A careful analysis, distinguishing between participants' own thoughts on the one hand and their retelling of the provided information on the other hand, is necessary to ensure construct validity.

The standardized questionnaire was used to collect socio-demographic data and capture participants' attitudes towards a range of statements concerning their views on seed production and breeding as well as information on their consumption behavior. The inclusion of a questionnaire allowed for data triangulation as is common in studies adopting a realist paradigm (c.f. Sobh & Perry, 2006).

### 3.2 | Data collection

Data collection took place in the district of Kreuzberg, Berlin, in July and August 2018. In total, 228 TAPs were collected in a conventional ( $n = 115$ ) and an organic ( $n = 113$ ) supermarket. We chose to collect data in both types of supermarkets because we suspected that organically minded consumers have a heightened awareness of social and environmental concerns and are thus a potential target group for open-source produce (c.f. Ditlevsen et al., 2020; Katt & Meixner, 2020). For recruitment, all shoppers who entered the supermarkets were approached and offered to sample the open-source tomato *Sunviva*. The purpose of this was to engage with shoppers and, hence, increase the likelihood of their participation in the study. Regardless of whether they choose to sample the tomato, they were requested to participate in a study related to the tomato. Subsequently, their consent was obtained and they were guided to a quiet part of the market, where they could choose to stand at a counter or sit down at a table. Each session consisted of four parts: (1) a practice round, (2) a thinking aloud task, (3) an explanation task and (4) a short questionnaire.

1. To allow participants to familiarize themselves with thinking aloud, they were asked to practice the method with an unrelated postcard that depicted a landscape and some text. They were instructed to follow three principles while looking at the

postcard: (a) to verbalize all thoughts that went through their head without purposefully structuring them, (b) to mumble or read aloud when reading text passages and (c) to take their time and continue until they had nothing left to say (c.f. Bantle & Hamm, 2014b, p.11; Heine & Schramm, 2007, p. 178). They were also told that there are no wrong answers. The practice usually lasted about 2 min.

2. For the thinking aloud task, participants were randomly assigned one of five flyers (see Section 3.3). Participants were told that their task is to understand the purpose and the function of the open-source seed license. The researcher refrained from intervening during the thinking aloud period but reminded participants to verbalize their thoughts if they fell silent for a longer period. If participants directed questions at the researcher while thinking aloud, they were told that all questions would be answered at the end of the session.
3. For the explanation task, we removed the flyers and instructed participants to imagine that they are meeting a friend or family member after their trip to the supermarket to whom they would like to explain the concept and purpose of the open-source seed license. They were told that this is not a test of how well they remembered the information on the flyer but that they could freely speak their mind. Having participants explain the license in their own words allowed for gaining additional insights into whether participants understood the concept, how they evaluate it and which aspects they consider most relevant. The verbalizations from both the thinking aloud task and the explanation task were audio recorded.
4. Finally, participants filled in a short questionnaire and submitted it anonymously. Besides questions on participants' socio-demographics, the questionnaire contained eight statements on seed production and breeding that participants rated on a 5-point Likert scale to indicate their (dis)agreement with the statements. It also included questions on participants' consumption behavior and their willingness to pay a premium for open-source produce.

### 3.3 | Stimuli

Five double-sided flyers served as stimuli for the thinking aloud task. Each flyer version used a different rationale for introducing the license. The rationales were as follows: (1) loss of *agrobiodiversity*, (2) high levels of *market concentration* in the global seed sector, (3) *privatization of plant genetic resources* through intellectual property rights, (4) open-source principles as *democratic means of production* and (5) the need for cultivars specifically developed for *organic agriculture*. The rationales correspond with the purpose of the license as specified by AGRECOL (Kotschi & Horneburg, 2018; Kotschi & Rapf, 2016). The front page of the flyer consisted of an image and a thematic slogan such as 'Agriculture needs crop diversity' (flyer 1) or 'No patents on my veggies' (flyer 3; see Figure 1). The back of the flyer had two parts. The first part informed participants about the purpose of the license based on the respective rationale (110–115





FIGURE 1 Flyers used as stimuli for the thinking aloud task (in German)

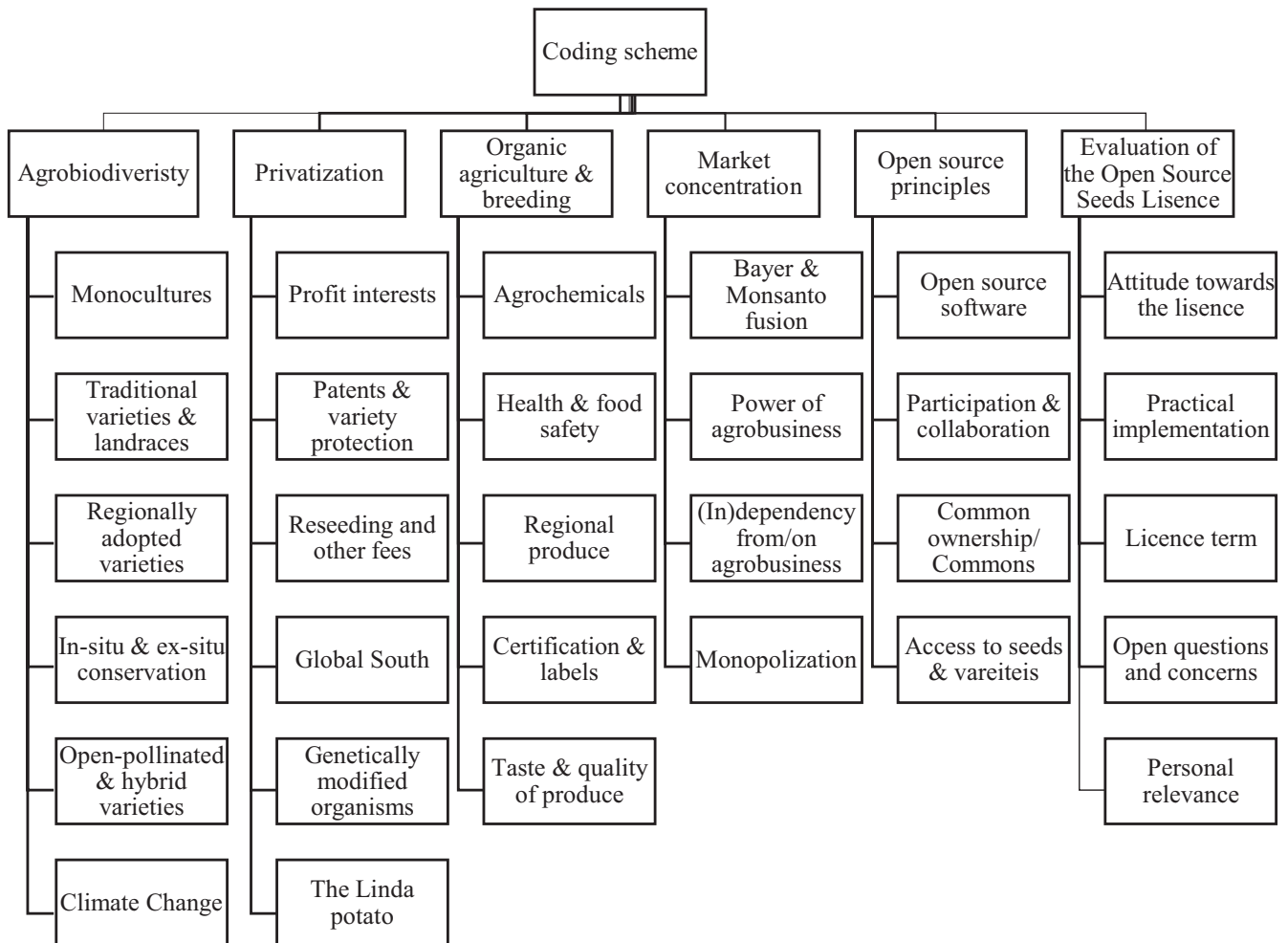


FIGURE 2 Coding scheme

words). The second part was the same across all flyers and spelled out the principles of the license (96 words), as specified on the initiative's web site:

'The license protects seeds and vegetable varieties from being controlled by few. Anyone who buys seeds with this license must follow three rules:

- Anyone may use open-source seed, grow it, propagate it, and develop it further through breeding. The seed and any further developments of it may be sold, exchanged, or given away within the framework of existing laws.
- No one is allowed to privatize the seed and its further developments; patents and plant-variety protection are thus excluded.
- Each recipient transfers the same rights and obligations to future users of the seed and its further developments'.

The flyers were tested and adapted in two rounds of pre-tests with 15 participants each.

### 3.4 | Analysis

We transcribed all recordings (average length: 7:30 min) following the transcription rules developed by Dresing and Pehl (2017) and developed a thematic category-based coding scheme (see Figure 2) following Mayring (2000). The flyer themes and consumers' evaluation of the license were used as main categories. Sub-categories were developed inductively, based on 30 randomly chosen transcriptions. The inductive approach necessitated from the lack of previous empirical studies and an absence of theory development on consumer perceptions of open-source seed licenses. After the analysis of 30 transcripts, a point of saturation was reached and no additional categories could be identified. Two independent coders coded all transcripts, using the software MAXQDA. In total, 2880 text segments were assigned to one or several categories. The inter-coder reliability, which indicates the extent to which the two independent coders agreed on the coding of the content, was 87.3 percent. This is an excellent value that points to a well-designed coding scheme with distinct and clear categories. On completion of the coding process, we revised our original categories, for example, through merging

or renaming sub-categories, to accurately reflect the entirety of the data. Sub-categories that related to several of the main categories (e.g., climate change was linked to both agrobiodiversity and organic agriculture) were assigned to the category that they were brought in connection with most frequently.

The subsequent qualitative content analysis following Kuckartz (2016, p. 45) focused on identifying reoccurring themes and statements that provide information on participants' perceptions of the open-source seed license. We distinguished between statements referring to participants' problem awareness, their solution perception and their evaluation of the license (see Table 1). Comments on the flyer design were excluded from the analysis as they provide no relevant information regarding the research questions. We analysed the data for the thinking aloud task and the explanation task separately. However, the results are presented conjointly for reasons of space and coherence.

### 3.5 | Sample

Table 2 provides an overview of the socio-demographics of the sample. There were no statistically significant differences between the two samples, except for education. On average, participants in the organic supermarket were more educated. Noticeably, participants across both samples were relatively well educated (>70 percent held a university degree, compared to 17 percent of the German population aged 15 or above). As to be expected, there were significant differences in the reported shopping behavior, with participants from the organic supermarket stating to be more likely to purchase organic produce ( $M = 1.48$ ,  $SD = 0.51$ ) than participants from the conventional supermarket ( $M = 1.97$ ,  $SD = 0.79$ ;  $t(217) = 4.412$ ,  $p = .000^{***}$ ). Participants from the organic supermarket ( $M = 1.82$ ,  $SD = 0.73$ ) also reported to pay more attention to labels than participants from the conventional supermarket ( $M = 2.04$ ,  $SD = 0.82$ ;  $t(221) = 2.046$ ,  $p = .041^*$ ). However, the difference in reported shopping behavior is relatively small.

TABLE 1 Analysis framework

	Problem awareness	Solution perception	Attitude
Definition	Problem awareness refers to the state or condition of being aware and having knowledge of a particular problem or challenge	Solution perception is the process of recognizing and interpreting information related to an action or process of solving a problem	An attitude is 'a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor' (Eagly & Chaiken, 1993, p. 1)
Research question	Which social and ecological sustainability challenges connected to seed production and breeding are consumers aware of?	How do consumers perceive open-source seed licenses and what properties do they attribute to them?	How do consumers evaluate open-source seed licenses?
Analysis criteria	Statements referring to sustainability concerns connected to seed production and breeding	Statements referring to the properties of the open-source seed license and the (potential) implications of introducing the license	Statements relating to participants approval or disapproval of the open-source seeds license



TABLE 2 Socio-demographic variables, self-reported shopping behavior and length of recording

Variable	Organic supermarket (n = 113)	Conventional supermarket (n = 115)	Overall (n = 228)	Population in Germany
Gender				
Female	59.3%	61.7%	60.5%	51% <sup>a</sup>
Male	38.0%	36.5%	37.3%	49% <sup>a</sup>
Other/no answer	2.7%	1.7%	2.2%	
Mean age	45.5	47.7	46.6	44.3 <sup>a</sup>
Education				
Secondary school diploma or less	2.7%	11.3%	7.0%	7.2% <sup>a</sup>
High school diploma	9.7%	7.4%	12.3%	19.5% <sup>a</sup>
Vocational training	9.7%	9.6%	9.6%	56.3% <sup>a</sup>
Bachelor's degree	14.0%	7.0%	10.5%	17.0% <sup>a</sup>
Master's degree or higher	62.8%	57.4%	60.1%	
Do not know/no answer	0.8%	0.0%	0.4%	
Monthly income (netto, per household)				
<1300€	21.2%	17.4%	19.3%	15.2% <sup>b</sup>
1300–2599€	18.6%	27.0%	22.8%	30.6% <sup>b</sup>
2600–3599€	11.5%	21.7%	16.7%	22.0% <sup>b</sup>
3600–5000€	18.6%	14.8%	16.7%	17.3% <sup>b</sup>
>5000€	13.2%	7.8%	10.5%	14.7% <sup>b</sup>
Do not know/no answer	16.8%	11.3%	14.0%	
Average household size	2.12	2.37	2.25	2.2 <sup>a</sup>
Purchase organic produce at least once per week [1 = very likely; 4 = very unlikely]	1.48	1.97	1.73	
Pay attention to labels (e.g. organic, FairTrade, regional) when purchasing food [1 = very likely; 4 = very unlikely]	1.82	2.03	1.93	
Average length of recording	7:15 min	7:45 min	7:30 min	

Sources: <sup>a</sup>Census 2011, <sup>b</sup>Statista Data from 2019.

## 4 | RESULTS: CONSUMER PERSPECTIVES ON THE OPEN-SOURCE SEED LICENSE

We first present the results from the questionnaire (Section 4.1). Subsequently, we present the results of the thinking aloud and the explanation tasks (Section 4.2).

### 4.1 | Questionnaire

Table 3 and Figure 3 show the results of the questionnaire. The first noteworthy result of our study is that there were no statistically significant differences between the two samples, except for the item *plant varieties should not be the private property of companies* which received higher support among participants from the organic supermarket ( $M = 1.31$ ,  $SD = 0.62$ ) than from the conventional supermarket ( $M = 1.60$ ,  $SD = 1.14$ ;  $t(219) = 2.301$ ,  $p = .021^*$ ). More than 80 percent of participants stated that they understand the principle of the open-source seed license. An even higher share of

89.9 percent supports the widespread introduction of the license, with nearly 69.7 percent strongly agreeing with the respective statement. The indicated support towards the open-source seed license slightly exceeded the support for open-source software, whose use 78.7 percent of participants favoured. Two-thirds of participants reported that they would be willing to pay a price premium for open-source produce. For 250 grams of tomatoes, which regularly cost 2.49 Euros, participants from the organic supermarket sample would on average be willing to pay a price premium of 49 Eurocents, which is slightly higher than the 42 Eurocents that participants from the conventional supermarket sample would be willing to pay.

### 4.2 | Thinking aloud and explanation tasks

In line with results from the questionnaire, the TAP revealed no substantial differences between participants from the two samples. On average, participants from the organic supermarket were only slightly more informed about seed production and breeding,

Questionnaire item	Organic supermarket	Conventional supermarket	Overall
Declining diversity in agriculture is a problem for our society	1.22	1.25	1.24
Patents are necessary to ensure progress in plant breeding	3.98	3.73	3.85
Plant varieties should not be private property of companies	1.31	1.60	1.46
It is a problem that a few large corporations dominate the seed market	1.25	1.20	1.22
I favour the use of open-source software	1.42	1.40	1.41
I understand the principles of the open-source seed license	1.77	1.80	1.79
I favour the widespread introduction of open-source seed licenses	1.32	1.37	1.35
I would be willing to pay a price premium for produce from open-source varieties	1.87	2.10	1.99
For 250 g tomatoes, which regularly cost 2.49€, I would be willing to pay a maximum of ___ Eurocent more if they were from an open-source variety	49 Eurocent	42 Eurocent	45 Eurocent

TABLE 3 Overview questionnaire responses

Note: Averages whereby 1 = strongly agree, 5 = strongly disagree; do not know/ no answer was excluded.

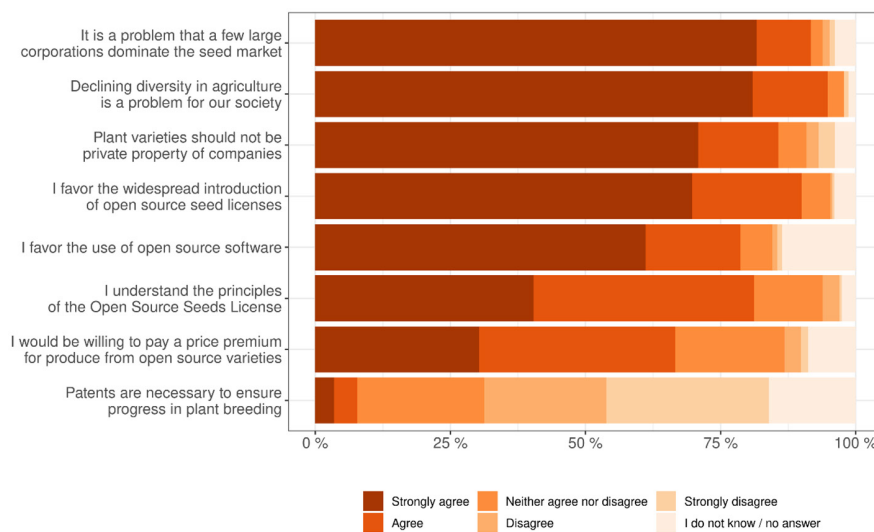


FIGURE 3 Agreement with various statements in percentages (overall sample)

which often led to more detailed verbal accounts. Because we did not observe any significant differences in either the frequency with which participants referred to different topics or their stated perceptions of the open-source seed license, we present the results conjointly.

Table 4 shows the frequency of the topics, including sub-codes, with which participants talked about during the thinking aloud and/or the explanation tasks. As expected, the topic of the assigned flyer version influenced what participants spoke about. However, it is noteworthy that irrespective of their assigned flyer version, all participants brought the open-source seed license in connection with several different topics. Open-source principles in general, privatization, and agrobiodiversity were most frequently addressed, with at least three-quarters of participants referring to these topics. The

license was least frequently brought in connection with organic agriculture. Because we did not observe any major differences between the TAP of different flyer versions other than the frequency at which topics were addressed, we do not further differentiate the analysis between the different flyer versions.

#### 4.2.1 | Problem awareness: Perceived sustainability challenges related to seed production and breeding

Participants referred to five main sustainability challenges as they verbalized their thoughts. These concerns were raised regardless of the flyer version received, although the stimuli influenced the likelihood of participants addressing a particular concern.

TABLE 4 Frequency of codes assigned by flyer version

Main code category	# of codes assigned	% of participants referring to the topic					
		Overall (n = 228)	Flyer 1: Agrobio diversity (n = 46)	Flyer 2: Market Concentr. (n = 46)	Flyer 3: Gen. open-source principles (n = 45)	Flyer 4: Privatization (n = 46)	Flyer 5: Organic agriculture (n = 45)
General open-source principles	522	85%	72%	87%	96%	85%	87%
Privatization	432	77%	76%	80%	67%	89%	73%
Agrobiodiversity	418	75%	93%	76%	67%	80%	58%
Market concentration	355	71%	70%	89%	69%	61%	67%
Other topics	260	57%	76%	61%	44%	48%	56%
Organic agriculture	254	50%	37%	54%	36%	46%	80%

Note: The color indicates the percentage of participants referring to the topic. The color coding is as follows: ≤30% 30–49% 50–69% 70–89% ≥90%.

The most frequently (n = 171) raised concern was the decline of agrobiodiversity. Especially the loss of old (heirloom/traditional/farmers) varieties, that may not be profitable, was feared. In this context, participants frequently told personal anecdotes of no longer available varieties that they remembered from when they were younger and which they associated with a distinctive taste, shape, colour or consistency. Monoculture production was most often blamed for the decline in crop diversity: *So many crops are lost because of the monocultures. It's a great pity. Probably the original ones too. For example, very tasty tomatoes that you might not find any more* (participant #046).

A second major concern was the increasing influence and power of large-scale multinational companies (n = 156). Participants frequently feared that the profit-orientation of agricultural companies may lead to a neglect of social and environmental considerations. A common belief in this context was that farmers, especially small-scale farmers in the Global South, are increasingly dependent on agricultural companies, which was widely perceived as unfair or bearing the danger of exploitation. The recent merger of Bayer and Monsanto was mentioned frequently as an example for increasing market influence and monopolization, although Monsanto was occasionally confused with other companies such as Nestlé or BASF: *There are large corporations, some of which are merging, such as Monsanto and Bayer. Then they have a monopoly. And they tinker with the seeds and have all the power. [...] I don't want that* (participant #030).

Another frequently mentioned concern was the health and environmental impact of agrochemicals (n = 86). Personal health concerns related to pesticide intake from food consumption and environmental damage through soil and water pollution were common concerns in this context. However, only a few participants drew the connection to seed production and breeding, with some participants arguing that a focus on varieties geared towards the use of agrochemicals may inhibit transitions towards sustainable agricultural practices: *The varieties of the big companies [...] are geared towards mineral fertilizers, pesticides. [...] We definitely have to overcome chemical inputs. It is harmful to us and the environment* (participant #032).

A fourth concern was the reduction in the quality and taste of produce (n = 66). Participants were particularly concerned about a decrease in nutritional value and flavour due to a focus on other breeding goals such as yield, stock quality and appearance. Modern industrial varieties were argued to be overbred, at the expense of qualities that are of highest importance for consumers: *I think the overbred varieties all taste like water. If I close my eyes, I can't tell if I am eating a cucumber or a tomato. [...] That really shouldn't be the case* (participant #167).

A fifth concern was the potential consequence of the introduction of GM varieties (n = 64). Here, participants most often feared that genetic changes in varieties may be uncontrollable or irreversible and that GM products may not be labelled as such. Participants frequently stated a loss of trust in the food industry in this context: *It is a huge problem that one has to be afraid to only get food on the plate that is genetically manipulated [...]. My trust in agricultural production has been completely lost because of that* (participant #197).

#### 4.2.2 | Solution perception: Perceptions of the open-source seed license

*From software to seeds: Transferability of the open-source concept*  
Transferring open-source principles from software to seeds was intuitive for many, but not all participants. Most participants ( $n = 191$ ) were familiar with open source as a concept, and many ( $n = 134$ ) drew connections to creative commons licenses or open-source software. However, transferring the concept from the digital sphere to physical goods was challenging for some participants ( $n = 42$ ). Especially older participants, who were often unfamiliar with open source as a concept, struggled to understand the principles underlying the license: *Open-source seeds are seeds that every farmer can use. Or so? Huh? No, I am not able to explain it. I know open source from software, but for seeds? It does not make any sense to me in this context* (participant #021).

*Open-source seed licenses as a means to counteract privatization*  
The license was widely ( $n = 174$ ) understood as a tool to prevent the privatization and commercialization of seeds and varieties. As such, the license was considered to propagate an alternative model of seed production, which counteracts profit-driven industrial agriculture based on intellectual property rights. Especially in the explanation task, many participants ( $n = 154$ ) stated that they believe that the main purpose of the license is to protect varieties from patents and other forms of privatization or commercialization: *In principle, [the license] means that the seeds [...] should be freely available to everyone and can be further developed [...]. The seeds should not be privatized. They are a public good and should remain so* (participant #032).

Participants frequently ( $n = 143$ ) assumed that an open-source scheme would lead to improved access to seeds and planting materials. In this context, some participants referred to the freedom to share and sell seeds ( $n = 69$ ), some highlighted the freedom of being able to reseed ( $n = 47$ ), and others pointed to the freedom of using open-source seeds as breeding material for new varieties ( $n = 27$ ). In the explanation task, the license was often ( $n = 41$ ) described as leading to collaborative breeding efforts and increasing farmers' and gardeners' participation in variety development: *With open-source seeds, everyone can participate [...] you can see which of the different seeds work best in the local soil and then of course pass that information on to other users. This is practically a joint effort to develop these seeds* (participant #144).

A frequently cited example ( $n = 21$ ) for potentially negative consequences of private ownership was the case of the popular organic potato variety *Linda*. The variety was taken off the market in 2005, when its variety protection license expired, stirring public outrage and protest: *There is the story with the Linda potato that was supposed to be withdrawn from the market because after 30 years the license expired, and the company would not have made any profit with it. [...] That's what happens without open source* (participant #070).

Participants sometimes ( $n = 33$ ) argued that varieties have been developed over many generations of farmers and that further

breeding progress alone would not justify the privatization of genetic resources. However, other participants ( $n = 26$ ) pointed to the need for patents and variety protection licenses as necessary financial incentivization to stipulate innovation and reward breeding efforts. Most of these participants ( $n = 24$ ) questioned the financial viability of open-source varieties and stressed the lack of business models to finance variety development under open-source schemes. Only a few participants ( $n = 28$ ) stated that they had not previously heard or thought about the privatization of genetic resources.

*Open-source seed licenses as a driver for agrobiodiversity conservation*

More than half of the participants ( $n = 158$ ) believed that the open-source seed license facilitates the conservation of agrobiodiversity. In the explanation task some ( $n = 49$ ) argued that seed production independent from profit-oriented agrochemical companies would foster crop diversity: *If there are only a few large companies that determine the prices and how seeds are produced, they can limit the diversity of varieties and determine which varieties are produced. So, it's mostly diversity aspects. [...] Open source culture is a kind of safeguarding the plants, so that plant diversity is preserved* (participant #097).

Participants also frequently ( $n = 33$ ) reasoned that the open-source seed license could help to avoid agricultural intensification and monoculture production. Yet, they often remained vague as to how exactly the license could help to foster diversified agricultural practices. Several participants ( $n = 31$ ) stated that they believe that the license facilitates the development of locally adopted and/or more robust varieties and as such contributes to climate change adaptation: *Especially because of climate change it would be good to have as many different varieties of plants as possible that can [...] adapt to changing climate conditions. And for that, there are these open-source licenses, I think* (participant #011).

The protection of traditional varieties and landraces was also frequently ( $n = 36$ ) referred to. Some participants falsely believed that the license contributes to agrobiodiversity conservation by protecting and/or (re)introducing traditional farmer's varieties: *It is an organization that is committed to raising awareness [and ensure] that old varieties are available for [...] our grandchildren and for us* (participant #076). The license, which is only applicable to newly bred varieties, was, thus, falsely seen as an instrument to promote traditional varieties and ensure their long-term protection.

*Open-source seed licenses as a tool against market concentration*

Participants commonly ( $n = 116$ ) speculated that the license could serve as a tool to prevent further monopolization in the seed sector by increasing seed supply channels. This, they argued, could lead to a reduction of farmers' dependency on profit-driven agribusiness ( $n = 95$ ): *There are increasing problems, with large parts of the world's seeds being developed and owned by a few corporations [...]. Farmers are becoming increasingly dependent since it breaks with the tradition that they harvest their own seeds for the next year. [The license] counteracts this and [...] tries to keep them freely accessible [...], so that farmers are not dependent on these corporations* (participant #071).

Furthermore, many ( $n = 84$ ) believed that the widespread introduction of the license could lead to a redistribution of power and thereby to a democratization of the agricultural sector: *Perhaps you could say it is all about the democratization of seeds. [...] The seeds and vegetables are no longer governed by a monopoly. [...] It's a power shift leading to democratization. [...] So varieties remain a common good* (participant #116). A number of participants ( $n = 41$ ) mentioned hybrid varieties or the need of farmers to rebuy seeds every year, with some participants ( $n = 13$ ) assuming that the license would only cover open-pollinated varieties and, thus, enable farmers to save their seeds and replant them. Noticeably, several participants ( $n = 39$ ) assumed that especially small-scale farmers would benefit from the license and improved access to seeds. Some participants ( $n = 32$ ) believed that farmers in less developed countries would be the greatest beneficiaries of the license.

#### *The impact of the open-source seed license on sustainable agriculture*

A number of participants ( $n = 34$ ) argued that the license would support organic agriculture, but this was primarily stated by participants who received the flyer on organic agriculture and breeding: *This is an initiative that supports organic farmers in gaining access to seeds that are not patented. [...] Open Source Seeds is about promoting organic agriculture, yes, exactly* (participant #170). Many of these participants pointed to agricultural companies' business models based on selling seeds with complementary agrochemicals and argued that the license could inhibit this trend. As such, the license was brought in connection with more natural production ( $n = 26$ ). Moreover, open-source produce was occasionally assumed to have higher nutritious qualities ( $n = 27$ ) and better taste ( $n = 18$ ) than industrial varieties. However, other participants ( $n = 26$ ) were concerned that open-source licenses may lead to a decline in the quality of seeds and varieties. These participants feared that the license would stimulate breeding experiments and lead to amateur varieties below industry standards, with some ( $n = 18$ ) assuming that the license would exempt breeders from any quality controls by the authorities.

Only a few participants associated genetic modification with the license and the assumptions made with regards to this topic varied widely. Although some participants ( $n = 34$ ) assumed that the license would not apply to GM varieties, others ( $n = 24$ ) were unsure if this was the case. In this context, some participants ( $n = 22$ ) supposed that plants, rather than genetic sequences or biotechnological inventions, can be patented in the European Union, which is not the case at present.

#### *Confusion about the term license*

Nearly one-quarter of the participants ( $n = 48$ ) considered the term open-source seed license as misleading. These participants argued that they associate restrictions and constraints with the term license, which contradicts the free nature and accessibility of open source. Some of these participants ( $n = 26$ ), thus, questioned why a new type of license was necessary to oppose patents and

commercial variety licenses: *Open Source Seeds License, if that's the term, I don't think it's that good. [...] So, it's accessible to everyone, but if there are licenses, it is exclusive - some have licenses [...] and others do not. So that's misleading somehow, it's a contradiction* (participant #080). There was also occasional confusion about who would hold such a license, and participants sometimes ( $n = 16$ ) believed that the license must be purchased or obtained by the farmer who wants to plant the seeds.

#### 4.2.3 | Attitude: Evaluation of the open-source seed license

All but three participants were completely unfamiliar with the open-source seed license and had never heard of it. Regardless, a large share of participants had a highly positive attitude towards the license. Although some participants ( $n = 43$ ) felt that they did not have enough information to form an opinion about the usefulness or necessity of the open-source seed license, the great majority ( $n = 169$ ) expressed a clear preference for the widespread adoption of the license: *This Open Source Seeds License is new to me. But if there is such a thing, that's great. [...] It should definitely be used by many who have to do with it'* (participant #004). When describing the license, participants frequently used terms such as *supportable, (very) relevant, (highly) important, genius, dearly needed solution or the right way*. Noticeably, even participants who were unable to explain the license in the explanation task often expressed a positive attitude towards the license. In some cases ( $n = 23$ ), participants reasoned that they favour open source in general and hence support the license, despite not fully understanding its implications for the agricultural sector.

Sixteen participants rejected the concept or were critical of it. These participants did not see the necessity of adopting open-source principles in the seed sector, were unsure about how the license can help address sustainability issues, or suspected a hidden agenda or profit interests of the initiators: *I am wary here. This seed license - who gets it and who decides about it? Who is behind this with which interests and intentions? And who controls and audits? I am very skeptical that this will work* (participant #206). Mistrust in the organization behind the open-source seed license seemed to be a major factor in the negative evaluation of the license.

Several participants ( $n = 36$ ) pointed out that they would welcome the introduction of an open-source seeds label to identify open-source produce. Others ( $n = 24$ ) expressed the concern that in the face of the multiple demands placed on consumers to make ethical purchasing decisions, they would not be able to consider yet another sustainability aspect. Some participants ( $n = 21$ ) questioned the relevance of the license for consumers altogether, arguing that the license had no relevance to them or that their personal scope of action was limited: *I don't know what they expect from me as a consumer. Because I don't have much to do with seeds. Unless I want to grow something on my balcony. But otherwise, I don't know - what do I have to do with seeds?* (participant #155). Table 5 summarizes the results of this section.



## 5 | DISCUSSION

Open source as a new type of ownership for varieties was largely unfamiliar to participants, but both the TAP and the questionnaire results indicate that most participants have a highly positive attitude towards the open-source seed license. Noticeably, they seem to favour the concept, regardless of whether they fully understood its functioning and consequences or not. There are several possible explanations for this, which require further exploration and validation: (1) Participants identified with the overall purpose of the license, but did not have enough knowledge or mental resources to fully understand the concept; (2) the positive connotation that most participants had with open-source software and/or creative commons licenses may have carried over to the open-source seed license; (3) the simple reflection on the topic during the thinking aloud task may have contributed to participants favourable attitude towards the license (c.f. Gielissen, 2011); (4) the non-profit orientation of the initiative generated enough trust in participants for them to evaluate the license as a supportable cause, without fully understanding it or (5) participants may have assumed that the research team expects them to evaluate the license positively and may have thus been subject to a social desirability bias.

The open-source seed license was widely perceived as a counter-model to current industrial seed production that inhibits the privatization of genetic resources, conserves agrobiodiversity, enhances farmers' access to seeds and ensures their independence from large-scale industrial companies. The privatization of genetic resources was mostly rejected on ethical grounds and often perceived to be part of a larger shift towards increasing power accumulation by agribusiness that steered mistrust and disapproval. Confirming the results of a study by Oehen et al. (2020), we can, thus, conclude that German consumers prefer food systems that support farmers' autonomy and enable farmers to take an active role in variety development. Possibly based on a romanticized view of small-scale agriculture, the prospect of supporting small-scale farmers through open-source seed licenses was particularly appealing for some consumers. This supports the notion that preferences for socially

responsible products are highly dependent on perceived beneficiaries (Tully & Winer, 2014), with small-scale farmers typically receiving a high level of support (Moser et al., 2011). The license was also assumed to lead to a democratization of the sector and improve access to seeds by granting the freedom to sell and share seeds without restrictions. Limited access to seeds and genetic resources was, however, not perceived to be a significant sustainability challenge.

Loss of agrobiodiversity was identified as a major sustainability concern that open-source seed initiatives aim to address. Here, it was often falsely assumed that the license particularly contributes to the preservation of traditional varieties, which was evaluated positively. These results are in line with studies concluding that traditional varieties are typically associated with exceptional sensory characteristics and cultural heritage and, thus, valued more highly than modern varieties (Botelho et al., 2018). However, the open-source seed license only applies to newly bred varieties, and the assumed focus on traditional varieties was the most common misconception. It highlights consumers desire for preserving known varieties (Cerjak et al., 2014), as well as their lack of understanding of the need to breed new varieties that are adapted to current agricultural and environmental conditions. Sustainability-related aspects that directly impact consumers such as the use of agrochemicals or the breeding of GM varieties were identified as sustainability concerns, but only seldom brought in connection with the open-source seed license.

Open source as a new credence attribute allows consumers to engage in critical consumerism and express their preferences regarding ownership rights of varieties and mode of seed production through 'buycotting'. This presupposes transparency on which varieties are open source through the introduction of a label. Labels are always a reduction of information complexities. As outlined above, they can facilitate consumption choices by creating a guiding narrative or storyline that stands for certain production processes. The environmental, economic and socio-cultural impacts of open-source varieties are complex and require an understanding of seed production and breeding that goes beyond common knowledge. To be effective, labels and their associated communication strategies need

TABLE 5 Summary of results from the thinking aloud protocols

Problem awareness	Solution perception: Beliefs about the open-source seed license	Attitude towards the open-source seed license
<ul style="list-style-type: none"> <li>Decline of agrobiodiversity, especially the loss of old varieties</li> <li>Increasing influence and power of large-scale multinational companies</li> <li>Health and environmental impact of agrochemicals</li> <li>Reduction in quality and taste of produce</li> <li>Consequences of the introduction of genetically modified varieties</li> </ul>	<ul style="list-style-type: none"> <li>Prevents the privatization of plant genetic resources</li> <li>Contributes to the conservation and enhancement of agrobiodiversity, especially old varieties</li> <li>Enhances (small-scale) farmers' access to seeds and encourages collaborative variety development</li> <li>Prevents market concentration and ensures the independence of (small-scale) farmers</li> <li>May contribute to sustainable agricultural production</li> <li>Unclear relationship with genetically modified varieties</li> </ul>	<ul style="list-style-type: none"> <li>Concept largely unknown</li> <li>Favourable attitude irrespective of understanding the concept</li> <li>Rejection of concept when there was a low level of trust in the initiators</li> <li>Some questioning the relevance of the license for consumers</li> </ul>

to focus on 'convincing consumers that [the attribute in question] confer[s] a value added to the consumer, even if the value relates to a broader public good aspect of the food and its production system'. (Moser et al., 2011, p. 134). Communicating the added value of open-source produce would, thus, require target-group specific narratives that on the one hand capture the essence of the license as a tool to inhibit the privatization of varieties and on the other hand highlight the immediate benefits and relevance for consumers (c.f. Lauterbach & Bantle, 2019; Meier & Oehen, 2019; Schaffner et al., 2015).

Especially for credence attributes, which are not easily verifiable for consumers, trust is highly important since consumers often suspect fraud or opportunistic behavior involved in certification processes (Vega-Zamora et al., 2019). AGRECOL, the organization behind the open-source seed license, is relatively unknown and their credibility was questioned by several participants in the current study. Establishing a credible certification agency and building consumer trust would thus be important first steps for marketing open-source produce under a labeling scheme. Because the term open-source seed license was counterintuitive for many participants, consumer communication could simply refer to open-source seeds, -tomatoes, -produce etc., to avoid confusion. Furthermore, the use of an English term proved difficult for participants that are less familiar with the English language, which were often older participants. As a communicative tool, open source may, thus, primarily appeal to younger and middle-aged, well-educated consumers that are either tech-savvy and familiar with open source as a concept or have a heightened awareness for sustainability concerns.

To what extent the positive evaluation of the license would translate into demand for open-source produce is highly uncertain. We have only examined *endogenous* factors (perceptions), neglecting *exogenous* and *structural* factors, that are crucial in predicting consumer behavior. As outlined above, it is well known that positive perceptions and attitudes alone do not necessarily translate into behavioral intentions (Bamberg & Möser, 2007; Fraj & Martinez, 2007) and that sustainability labels play overall only a minor role in consumer decisions (Grunert et al., 2014; Janßen & Langen, 2017). Perceived consumer effectiveness, resource constraints, and other factors that determine consumers' purchase behavior are not considered here. Most importantly, we have focused on perceptions rather than personal preferences (c.f. Lusk et al., 2014). Although consumers may positively evaluate open-source seed licenses, it remains unclear if these evaluations coincide with personal preferences for taste, health, safety and quality. Improved quality and taste of produce or health benefits were not commonly associated with the license and sometimes even questioned. Yet, these attributes are often major determinants of purchasing choices (Hughner et al., 2007; Moser, 2016; Rana & Paul, 2020).

A limitation, yet also a strength of this study is its non-representative sample, which is characterized by a large share of highly educated consumers that regularly purchase organic produce. Although the self-stated purchasing behavior differed significantly between the two samples, even in the conventional supermarket sample more than two-thirds of participants reported being (very)

likely to purchase organic produce at least once a week. These results are significantly higher than the national average (see Table 2) but are in line with findings from Marreiros et al. (2021) who observe a similarly high level of consumption of organic products in Berlin. In addition, the area of study, the Berlin district of Kreuzberg, is known for its high share of inhabitants with green-leftist political attitudes, which likely affected the results and may partially explain the overall highly positive evaluation of the license. However, this also bears the advantage that the sample has a clear overrepresentation of those consumer segments that most likely engage in critical consumerism and are, thus, the primary target group for open-source produce. Gaining insights into the perceptions of specifically those consumer segments is especially helpful for marketing purposes. Although the findings may not allow for generalizations to the larger German population, they do indicate that highly educated, organically minded consumers in urban areas are a suitable target group for open-source produce.

Methodological challenges lay in the explorative character of the method of thinking aloud. The method does not suit all personality types and it is difficult for some people to verbalize their thoughts while receiving new information. Furthermore, the setting can seem unnatural to participants, since they receive no feedback from the researcher during thinking aloud. This can lead to situations where participants filter their thoughts based on perceived expectations (Häder, 2015). For these and other reasons, TAP are often used in triangulation, for example in combination with survey data or post-experiment interviews, to support credibility (e.g. Risius et al., 2017). We chose to combine the method with a short questionnaire and the explanation task, which allowed us to provide a fuller and more credible picture of participants' perceptions.

## 6 | CONCLUSION

In recent years, open-source seed initiatives have been founded to ensure access to plant genetic resources for current and future generations. The first open-source produce is now entering consumer markets. With ownership properties of varieties posing a new credence attribute that gains in relevance as an increasing share of consumers attempts to purchase ethically and/or sustainably produced products, we examined German consumers' perceptions towards the German open-source seed license.

The open-source seed license is widely understood to provide a counter-model to current industrial seed and agricultural production. Specifically, it is believed to (1) prevent the privatization of plant genetic resources, (2) contribute to the conservation and enhancement of agrobiodiversity, (3) support (small-scale) farmers and (4) prevent market concentration.

Our findings make a valuable contribution to the marketing efforts of open-source produce by shedding light on the properties that consumers attribute to the license. We can conclude that by drawing upon a concept that consumers are likely already familiar with from open-source software or creative commons, open-source

seed licenses provide a communicative entry point that draws attention to specific sustainability concerns in the agricultural and food sector. The high level of approval for the concept indicates a marketing potential for open-source produce. As awareness for production conditions beyond farming methods and place of cultivation rises, open-source produce may act as a niche innovation that shifts power relations and influences regulatory frameworks to support sustainable seed production and breeding. Nevertheless, open source as a new type of variety ownership remains a novel aspect for consumers and will require the deliberate creation of narratives that relate to consumers' needs and preferences. The introduction of an open-source label would provide the transparency that is necessary for consumers to distinguish open-source produce. Since other sustainability aspects such as local and organic production will likely remain consumers' primary sustainability concerns in the foreseeable future, it is worth considering integrating the open-source concept into the standards of well-established certification systems and labels.

The research is of relevance to gain a better understanding of the role of consumers in safeguarding biodiversity through consumption choices and the potential of such licenses for steering consumer behavior. The paper contributes to a rising academic discourse on sustainable consumption and critical consumerism (c.f. Paul & Bhukya, 2021), by introducing a new credence attribute that has previously not been explored: variety ownership. Our research shows that, although abstract in its nature, consumers are able to link the concept of open-source varieties to sustainability concerns, specifically agrobiodiversity loss – a topic whose complexity is difficult to convey to consumers (c.f. Bantle & Hamm, 2014a, b; Kleinhüchelkotten et al., 2006). By drawing attention to a potential new label, the research also contributes to discourses on eco-labels.

Policy implications include the need to support the introduction of a trustworthy and credible open-source label that relates to consumers' needs and preferences and enables breeders and seed companies to establish open-source varieties as sustainable alternatives to industrial private property-based varieties. Diversified food systems, based on participatory on-farm breeding and diverse seed- and production systems, foster resilient food- and agricultural systems that are needed to face climate change and other socio-ecological challenges of the 21st century (Kliem & Sievers-Glotzbach, 2021; Lammerts van Bueren et al., 2018; Meier & Oehen, 2019). Yet, open-source produce can pose only one of several elements of a larger policy framework conducive to the preservation and enhancement of genetic diversity.

We propose three main future research directions: (1) Further research may examine consumers' willingness to pay for open-source produce, especially in relation to other sustainability attributes such as organic and regional production or fair trade. This could provide insights into the relational importance of variety ownership as a sustainability-related credence attribute. In this context, the potential integration of open-source aspects in existing labeling and certification schemes could also be explored further. (2) It would

be interesting to examine consumers' perspectives on open-source seed licenses in other industrialized countries to allow for greater generalizations on the potential of open source as a new credence attribute. (3) Additional empirical research on specific open-source foods is necessary. Because this study focused on fresh produce, it would be valuable to examine the perceptions and marketability of processed food based on open-source varieties such as open-source bread, -pasta or -cookies.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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