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Consumers' preferences for commons-based and open-source produce: A discrete choice experiment with directional information manipulations

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ABSTRACT

The increasing privatization of seeds and varieties through intellectual property rights such as patents and exclusive seed multiplication rights has led to power imbalances and contributes to the continuous decline of genetic diversity. Diversified agricultural systems are, however, essential for climate change adaptation and the long-term resilience of our food systems. Common ownership of seeds and varieties can play a central role in supporting the development of diversified agricultural systems. With the first commons/open-source varieties entering consumer markets, consumer preferences and willingness-to-pay (WTP) for these varieties are worth exploring. On the example of tomatoes, we carried out a representative consumer survey with a discrete choice experiment. We find that consumers prefer commons/open-source varieties to company-owned varieties and are willing to pay a premium for these varieties. However, the premium they are willing to pay is smaller than for locally grown and organic produce. Providing additional information on the advantages of commons/open-source varieties positively affects WTP. There are no differences in WTP values for 'commons varieties' and 'open-source varieties'. Our findings contribute to academic and policy discourses on consumers' role in agro-biodiversity conservation and enhancement.

1. Introduction

The increasing privatization of seeds and varieties through intellectual property rights such as patents and exclusive seed multiplication rights has contributed to a decline in crop species and genetic diversity, threatening long-term food security (Frison et al., 2011). However, crop genetic diversity is crucial for climate change adaptation, building agroecological resilience, and transitioning toward sustainable food systems (Altieri et al., 2015; Altieri & Nicholls, 2017; Corrado et al., 2019; Jager et al., 2019; Labeyrie et al., 2021; Lamine & Dawson, 2018; Lammerts van Bueren et al., 2018). Private ownership of crop varieties and genetic sequences by a few large-scale global agribusinesses has been criticized for causing power imbalances, a lack of democratic participation, and high dependence of farmers on corporations (Bonny, 2017; Howard, 2015, 2016). Most large-scale agribusinesses focus on genetically uniform, high-performance hybrid varieties that are particularly profitable (Kotschi et al., 2022). This narrow focus may lead to further genetic erosion (Bhandari et al., 2017; Fu, 2015).

Food policy debates have hence evolved around strengthening food security and agroecological resilience through genetic-, crop- and biocultural diversification (e.g., Argumedo et al., 2021; Dempewolf et al., 2023; Lammerts van Bueren et al., 2018). Furthermore, there has been a growing interest among farmers and civil society actors in self-determined and democratic food systems which prioritize local control over seed and plant genetic resources (Da Via, 2012; Lyon et al., 2021; Kloppenburg, 2014). Especially calls for seed sovereignty, which entails the right of farmers and communities to control and manage their seed systems, including the freedom to save, exchange, and utilize locally-adapted seed varieties, have gained significant prominence (Peschard & Randeria, 2020). This aligns with a growing demand for more equitable and sustainable food systems that prioritize local communities' and farmers' needs and interests (e.g., Hammelman et al., 2020; McGreevy et al., 2022).

To ensure the long-term preservation and development of crop genetic diversity and counteract privatization trends, scholars and civil society actors have proposed to broaden access to plant genetic resources through shared ownership and collective management of seeds (Montenegro de Wit, 2017; Sievers-Glotzbach et al., 2020; Tamura,

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2022). Commons-based breeding and seed production thereby describes governance arrangements that enable the collective, polycentric management of seeds and varieties (Sievers-Glotzbach et al., 2020). Such governance forms have been associated with developing genetically diverse, locally adapted, open-pollinated, organic varieties (Kliem & Sievers-Glotzbach, 2021). The discourse on seed commons has also shaped food policy debates. In 2020, a group of German parliamentarians, for example, put forward a motion to *"recognize seeds as a common good and to provide increased support for the free exchange and breeding of traditional seeds*" (Deutscher Bundestag, 2020, p. 5).

One form of seed commons are open-source seeds licenses and -pledges. They (legally) ensure that seeds can be freely used, propagated, and developed and prohibit the privatization of varieties and any further developments thereof (Kloppenburg, 2014; Kotschi et al., 2022; Kotschi & Horneburg, 2018; Kotschi & Rapf, 2016; Luby & Goldman, 2016; Luby et al., 2016). The first of its kind, the US-based Open Source Seed Initiative, was established in 2012 and developed a pledge that is now applied to over 550 varieties. Similar pledges and licenses have since been developed in Germany, Italy, Argentina, Mexico, Kenya, Tanzania, Uganda, Thailand, and India (Global Coalition of Open Source Seed Initiatives, 2022). In a food policy context, these pledges and licenses have received little attention, but information campaigns by non-profit organizations have popularized the concept (see e.g., Heinrich Böll Stiftung, 2018).

In these contexts, the role of consumers in safeguarding genetic and crop diversity has been raised, posing the question of whether consumers are willing to pay for produce that is marketed as supporting the conservation of agrobiodiversity and inhibiting the privatization of genetic resources (e.g., Hamm et al., 2016; Meier & Oehen, 2019; Kliem & Wolter, 2022; Lamers et al., 2016). Consumers' preferences and willingness-to-pay (WTP) for commons/open-source varieties have previously not been examined but are crucial for exploring consumers' role in agrobiodiversity conservation through purchasing decisions. Commons/open-source varieties are currently a niche phenomenon, and consumer demand for these varieties remains unclear. If consumers are willing to compensate breeders and seed companies for their efforts to diversify breeding and agricultural production, this should be reflected in higher WTP values for commons/open-source varieties than for private, company-owned varieties (Meier & Oehen, 2019). Variety ownership is thereby a new sustainability-related credence attribute (Kliem & Wolter, 2022). Credence attributes are product qualities that are not easily observable or verifiable for consumers during purchase or consumption (Darby & Karni, 1973; Fernqvist & Ekelund, 2014). Contrasting to search attributes (e.g., price) or experience attributes (e.g., taste), credence attributes cover intangible features that impact nature and society along the entire value chain. They shape a wider understanding of food quality, including environmental, social, and ethical concerns (Torjusen et al., 2001). The added value of sustainability-related credence attributes is frequently associated with price premiums, especially if food products carry a label that certifies a specific standard.

Gaining an understanding of consumers' preferences and WTP for commons/open-source varieties allows for determining the potential of these approaches to support a sustainable transformation of the seed sector. Studies show that a significant share of consumers is willing to pay for other sustainability-related aspects, such as organic and local production, fair trade, low carbon footprints, plastic-free packaging, and animal welfare (e.g., Feucht & Zander, 2017, 2018; Grebitus et al., 2013; Hempel & Hamm, 2016 a, b; Herrmann et al., 2022; Illichmann & Abdulai, 2013; Janssen & Hamm, 2012; Meyerding et al., 2019; Paetz & Guhl, 2017; Yeh & Hartmann, 2021). Examining WTP values for commons/open-source produce in relation to other sustainability attributes, such as organic and local production, is relevant to realistically map consumer preferences and acknowledge that purchasing decisions are complex and require weighing up different (sustainability) attributes. Given the novelty of commons/open-source varieties, consumers are likely unfamiliar with the concept. It is hence interesting to explore if and how the provision of additional information or the framing of the concept shape consumers' preferences and WTP values for these varieties.

On the example of fresh tomatoes, we carried out a survey including a discrete choice experiment to address the following research questions: (1) What is consumers' WTP for commons/open-source varieties compared to private, company-owned varieties? (2) How does consumers' WTP for commons/open-source varieties compare to their WTP for other sustainability-related credence attributes such as local production and organic cultivation? (3) Which (if any) effect has the framing of the ownership attribute as 'commons variety' vs. as 'open-source variety' on consumers' WTP? And (4) which (if any) effect has the provision of additional directional information (commons vs. industry narrative) on consumers' WTP?

2. Literature review

2.1. Purchase criteria and willingness to pay for (sustainability-related) attributes

Several studies have examined consumers' preferences for different attributes of fresh tomatoes. Jürkenbeck et al. (2020) used a discrete choice experiment to simulate a buying situation in a German supermarket and examined a range of experience attributes (color, size, taste, inner firmness, flavor, skin consistency) and credence attributes (regional production, organic label, from my region label, pro Planet label, GM-free label, climate label). Apart from price, they found red color and fruity taste to be the most important determinants of tomato purchasing decisions and identified six different consumer segments with varying priorities. Regionality and the various sustainability labels were most important for "balanced consumers" (about 20% of consumers) that pay attention to various attributes. Similarly, De Salvo et al. (2020) carried out a discrete choice experiment with the attributes tomato shape, color, skin- and pulp consistency, packaging, origin, production method, worker's health and safety certification, and eco-sustainability certification. They found that red color and country of origin (Italy rather than Spain, the Netherlands, Egypt, or Morocco) are key purchasing determinants, while the thickness of the tomato peel and the richness of the pulp had little relevance for consumer choices. Tomatoes with certified credence attributes were preferred to those without, with consumers being willing to pay the highest price premiums for organic certification, followed by eco-sustainability labels and workers' health and safety certification.

Aspects related to plant varieties, breeding, and seed production have so far rarely been included in studies examining WTP for tomatoes or other food items and have primarily focused on traditional heirloom varieties or the introduction of new breeding technologies (e.g., Götz et al., 2022). A qualitative study by Lauterbach and Bantle (2022) shows that consumers have little knowledge of heirloom varieties and only rarely pay attention to which varieties they buy. However, these varieties are associated with good taste, health benefits, and naturalness (Lauterbach & Bantle, 2022). There is evidence that these positive associations translate into a willingness to pay premiums for traditional heirloom varieties. Brugarolas et al. (2009), for example, find that a high percentage of consumers in south-eastern Spain would be willing to pay substantial price premiums for local, traditional tomato varieties. Similarly, Botelho et al. (2014) find the estimated price premium consumers are willing to pay for traditional tomato varieties in Portugal to be 35% relative to foreign varieties. Meier and Oehen (2019) examine Italian, Spanish, Austrian, and Swiss consumer preferences for varieties bred and multiplied by farmers. They find that consumers generally support the idea of farmers' varieties as a means to increase diversity in the food system and observe price premiums of 3–13% for tomatoes from farmers' varieties. Noticeably, farmers' varieties are not only appealing to consumers who prefer local and organic produce but also to

consumers for whom taste, appearance, and price are among the most important purchasing criteria. Preferences and WTP for commons/open-source varieties have so far only been explored in one small-scale study by Kliem and Wolter (2022), which is outlined below (see section 2.2, hypothesis 1).

Corresponding to our research questions, we derived the following four hypotheses for our empirical analysis:

Hypothesis 1. *Consumers prefer commons/open-source varieties over private varieties, which is expressed in a higher WTP for commons/open-source varieties than for private varieties.*

Plant variety ownership as a credence attribute has so far only been examined in a non-representative study with 228 respondents in Berlin, Germany. The study focused on open-source varieties and found self-stated WTP values of EUR 0.45 per 500 g of tomatoes, whereby consumers in an organic supermarket were willing to pay an average premium of EUR 0.49, and consumers in a conventional supermarket of EUR 0.42 (Kliem & Wolter, 2022). The study also showed that consumers have positive associations with open-source produce, regardless of whether they fully understand the concept. We expect to replicate these findings and hypothesize that consumers are willing to pay a price premium for commons/open-source varieties.

Hypothesis 2. *The WTP values of consumers for different sustainability attributes are as follows*: *WTP for local production* > *WTP for organic cultivation and breeding* > *WTP for commons/open-source varieties.*

A significant share of consumers favors organic and local production and is willing to pay a premium for these attributes (e.g., Hempel & Hamm 2016a). Studies consistently show that WTP values for local production are higher than for organic production or any other sustainability attribute (Ankamah-Yeboah et al., 2019; De Salvo et al., 2020; Hempel & Hamm, 2016b). We expect to observe this effect here as well. Support for the local economy plays a large role in purchasing reasons for local products, while organic production is often associated with health and environmental benefits (e.g., Apaolaza et al., 2018; Hempel & Hamm, 2016a; Nadricka et al., 2020). Both attributes are frequently perceived as indicators of product quality and are associated with good taste (Hempel & Hamm, 2016a; Schäufele & Hamm, 2017). Consumers' preferences for certified organic breeding and seed production (Bioverita certification) have, to our knowledge, not previously been examined. We expect that WTP values for commons/open-source varieties are lower than for local production and organic cultivation and breeding. We expect this to be the case since respondents are likely less familiar with the attribute and since it may, in comparison to local and organic production, be more difficult for consumers to see the immediate benefits of commons/open-source varieties for themselves and society as a large.

Hypothesis 3. *Consumers have higher WTP values for varieties referred to as* '*open-source varieties*' *than for varieties referred to as* '*commons varieties*'.

Previous studies show that the framing of the attributes significantly affects WTP values. Kulesz et al. (2019), for example, find that including the term biotechnology significantly increased variation in WTP for hormone and triploid-treated salmonids. Similarly, Zheng et al. (2022) find that consumers have a higher WTP for organic labels than pesticide-free labels. Although these labels are not identical, they largely overlap in their claims, supporting the hypothesis that framing can influence WTP values. To our knowledge, there are no studies on the framing effects of open-source and commons varieties. However, the study by Kliem and Wolter (2022) finds that consumers have highly positive associations with open-source produce. We expect that some respondents are familiar with and positively connotate open-source software products. They may hence be more acquainted with the term open-source, which may positively affect WTP values.

Hypothesis 4. *The provision of information affects WTP values of consumers for commons/open-source varieties as follows*: *commons narrative* > *no additional information* > *industry narrative*.

Several studies find that additional information about the valuation scenario affects WTP values for sustainability attributes such as organic production or fair trade (Disdier & Marette, 2012; McFadden & Huffman, 2017). Other studies find WTP values to be robust to additional information (von Grafenstein et al., 2022; Wuepper et al., 2019). Von Grafenstein et al. (2022) partially explain the robustness of WTP values with an already high level of familiarity with the attribute and overall high WTP values. Similarly, Wuepper et al. (2019) highlight the relevance of fundamental preferences. Studies on unfamiliar foods or certifications, such as insect-based food or carbon footprint labels, consistently observe effects of information provision on WTP values (Emberger-Klein & Menrad, 2018; Lombardi et al., 2019; Sogari et al., 2022). We hence expect information effects here as well. Especially since respondents are likely completely unfamiliar with the topic, we assume that providing information on the relevance of commons-based breeding will increase WTP values for commons/open-source varieties. We also expect that providing an industry narrative, which highlights the relevance of intellectual property rights, will negatively influence WTP values for commons/open-source varieties.

3. Methods

Germany was chosen as the country of data collection since, to our knowledge, it is the first country that has introduced open-source food items, which, at least on a few occasions, have been marketed explicitly as open-source, e.g., open-source bread was introduced in several bakeries in Berlin. We carried out a representative online survey with consumers from Germany from February to April 2021, which included a discrete choice experiment on consumer preferences for fresh tomatoes. Discrete choice experiments are a quantitative technique that reveals consumer preferences by asking survey respondents to choose between hypothetical product alternatives with specific attributes (Hensher et al., 2005; Hess & Daly, 2014). The method is used to elicit preferences and WTP values of consumers and is frequently employed in food research (e.g., Balcombe et al., 2014; Lizin et al., 2022). We decided to use a discrete choice experiment since it allowed us to hypothetically explore consumers' WTP for credence attributes that are not (yet) transparent in real-life supermarket settings – in this case, commons/open-source varieties. The survey had four parts: (1) questions on shopping behavior and socio-demographics, (2) a thematic introduction and an information treatment (only some respondents), (3) the discrete choice experiment, and (4) Likert-scale ratings of (dis)agreement with various statements.

3.1. Discrete choice experiment

In the discrete choice experiment, we asked respondents to imagine that they would like to buy tomatoes for their household in their everyday life. To control for potential seasonal effects, we asked half of the respondents to imagine that they are buying tomatoes in summer. The other half was told to imagine that they are buying tomatoes in winter. Respondents were subsequently presented with several choice cards that each showed two 500 g packages of tomatoes with different attribute combinations. They were asked to choose one of the tomato packages or choose neither. They were told that both available tomatoes are high quality (grade 1) and taste equally good. Before the experiment started, we asked respondents what kind of tomatoes they would like to buy. They could choose between small cocktail or cherry tomatoes and large salad or beef tomatoes. By doing so, we created a more realistic shopping situation adapted to the habits of the respondents.

The tomatoes were described by four attributes: Cultivation method, origin, ownership rights, and price (see Table 1). We provided respondents with a brief description of each attribute and their levels

Table 1
Attributes and levels of the discrete choice experiment.

Attribute	Description	Levels	Coding
Cultivation	Cultivation method used	Conventional	Reference
		EU-organic certification	Dummy (0,1)
		EU-organic certification + Bioverita certification	Dummy (0,1)
Origin	Location at which the tomato was grown	Local (within 75 km)	Dummy (0,1)
		Germany	Dummy (0,1)
		Spain	Dummy (0,1)
		Morocco	Reference
Ownership rights	Ownership rights of the variety	Private variety	Reference
		Open-source variety (sample A)	Dummy (0,1)
		Commons variety (sample B)	Dummy (0,1)
Price	Price per 500 g in EUR	0.99	Linear with original values
		1.49	
		1.99	
		2.49	
		2.99	
		3.49	
		3.99	
		4.99	

before they were confronted with the choice situations. The cultivation attribute had three levels: (1) conventional production, (2) EU organic certification, and (3) EU-organic certification + Bioverita certification. The Bioverita label certifies seeds and varieties that have been developed and multiplied under organic conditions and are specifically adapted to the needs of organic cultivation.

For origin, four attribute levels were included: (1) local production (within 75 km), (2) production in Germany, (3) production in Spain, which, together with the Netherlands, is the most important European supplier of tomatoes sold in Germany, and (4) production in Morocco, which is the most important non-European supplier (Statista, 2021).[1]

The attribute on ownership rights had two levels: (1) private variety and (2) open-source variety (sample a)/commons variety (sample b). Private varieties were defined as varieties that are developed by professional seed companies and are covered by intellectual property rights. For these varieties, only the company that bred the variety is allowed to propagate and sell the seeds. This enables seed companies to cover investment costs and make a profit from breeding. Such intellectual property rights expire after around 25 years. Private varieties are usually not reproducible, i.e., they can only be grown for one season. Seeds must thus be purchased by farmers and gardeners every year. In contrast, commons/open-source varieties were defined as freely available common-pool varieties that can be propagated, passed on, developed, and sold without restriction. The privatization of these varieties, for example, through patents or variety protection, is strictly prohibited. Commons/open-source varieties are usually registered with non-profit associations, who monitor the compliance with open-source/commons principles and can take legal action in case of infringements. These varieties are reproducible and can be propagated by farmers and gardeners themselves. This promotes their independence from commercial seed companies. The attribute descriptions for open-source varieties (sample a) and commons varieties (sample b) did not differ significantly in their wording. Respondents were randomly assigned to one of the two samples. The split sample was used to test whether respondents have different WTP values depending on the term used (see hypothesis 3).

Price levels varied from EUR 0.99 to EUR 4.99 for 500 g, which was a standard price range for 500 g of tomatoes at the time of the survey, although prices vary significantly with season and type of tomato. Fig. 1 shows a sample choice card.

We generated 72 choice sets, grouped in eight blocks with nine choice sets each. The choice design, which is an orthogonal foldover design, was generated in NGENE. It was checked for sets that include dominant alternatives. These were adjusted by row swapping while maintaining the orthogonality of the design. Each respondent was randomly allocated to a block, and the order of sets within a block was randomized. The order in which attributes appeared on the choice card was randomized between respondents but remained constant for each respondent. The design was extensively tested with Monte Carlo simulations and contrasted with other designs, such as Bayesian and efficient designs. While all tested designs provided unbiased estimates, we found the selected design to produce lower or the same standard errors with a lesser correlation between attributes than the other designs.

The survey design and the discrete choice experiment were tested and refined in six focus groups with six to eight participants each. The focus groups were carried out in Berlin, Munich, and Frankfurt in the summer of 2020. In addition, we carried out a pilot study with 201 respondents. After the pilot study, the experimental design was modified, and two attributes were omitted or refined.

3.2. Information treatments

To introduce respondents to the survey topic, they received information on the different production stages of tomatoes before completing the discrete choice experiment (see Fig. 2). In addition, they were randomly assigned to one of three information treatments: (1) commons narrative, (2) industry narrative, or (3) no additional text. The commons narrative highlights the negative consequences of the increasing privatization and market concentration of seed production and breeding, including the loss of crop diversity (see Fig. 3). The industry narrative highlights the importance of patents and other private property rights for financing variety development and producing high-quality seeds, as well as the contribution of professional seed companies to food security. These aspects are frequently emphasized by seed commons initiatives and large-scale seed companies, respectively. The text was reviewed by commercial breeders and staff from the Open Source Seeds Initiative. The information treatments were used to examine whether additional directional information impacts consumers' WTP for commons/open-source varieties (see hypothesis 4).

3.3. Sample

Respondents were recruited by a professional survey company through an online panel. They were eligible to participate if they (1) go grocery shopping for their household several times per month and (2) purchase fresh tomatoes several times per month. Respondents that did not meet these criteria were excluded from the survey. We set quotas for gender, age, education level, and income based on the latest available socio-demographic data. The sample is hence largely representative of the German population (see Table 2).

We collected 3,595 observations in total. To ensure data quality, we performed data quality checks. We excluded all respondents that took less than a third of the average response time to complete the survey since respondents who complete surveys at an unusually quick speed often produce unreliable results. The cut-off point of a third of the average response time was recently used in a similar study (c.f. Jürkenbeck et al., 2020). We also excluded all respondents that did not correctly answer a control question, which read as follows: "*This is a control question. Please respond with 'disagree' to this statement.*" The final sample included 3,147 respondents.

Table 3 shows the distribution of respondents across samples. No statistical differences concerning the socio-demographic characteristics could be observed between the samples. A detailed table including statistical test results comparing socio-demographic variables between

[1] In a pre-test, we included the Netherlands as an additional attribute level. However, the pre-test results showed no difference in preferences between the Netherlands and Spain. We, therefore, dropped the Netherlands from our final design.

	Tomato A	Tomato B	Neither
Price for 500 grams	3,99€	1,49€	
Cultivation	EU-organic certification	EU-organic + Bioverita certification	
Origin	From the region (within 75km)	From Spain	
Ownership rights	Open-source variety	Private variety	
Choose here			

Fig. 1. Sample choice card (translated from German).

From seeds to supermarkets: How do tomatoes get into our stores?

Tomatoes are the favorite vegetable of many people. On average, consumers in Germany eat over 27 kilograms of tomatoes per year. That is more than any other vegetable. But how do tomatoes get into our stores?

Breeding Seed multiplication Production Harvest & Processing Transport Consumption

©123RF, Anastasia Tukaeva

It all starts with the development of varieties. Seed companies develop tomato varieties for different environmental conditions. Tomato varieties differ in taste and appearance (e.g., shape and color).

The tomato seeds are propagated by seed companies and sold to farmers. Farmers sow the seeds and grow the tomato plants. Tomatoes need sunshine, warmth, and water to grow well. They are hence often grown in greenhouses.

When ripe, the tomatoes are harvested, weighed, and packaged. Next, they are transported to merchants and their place of sale. Consumers can then buy the tomatoes in stores and at markets.

Fig. 2. Introductory text on the production stages of tomatoes, which was presented to all respondents (translated from German).

samples is provided in the online supplementary material.

All respondents involved in the research provided informed consent before participating. A record of their consent is maintained. No human subjects were deceived during the research process and the research followed high ethical research standards guided by the ethical principles of the American Psychological Association.

3.4. Data analysis: Econometric approach and model estimation

To analyze the data from the discrete choice experiment, we estimated several models that included unobserved preference heterogeneity and compared the results to those obtained from conditional logit models without any heterogeneity. We decided to use a random parameters logit model in willingness to pay space (Train & Weeks, 2005), which provides a good model fit and reasonable distributions of WTP for all information split samples. While some models in preference space had a better model fit, they provided unrealistically high mean and median WTP values. Our model estimates are in line with basic conditional logit models with respect to magnitude and significance. In the online supplementary material, we provide an additional analysis with latent class models. These models provide further insights into the distribution of preferences. We do not report these models here since preference heterogeneity is not the focus of our research.

Based on the random utility framework, we assume respondents maximize utility over the set of given alternatives:

$$U_{nk} = \alpha_n ASC_k + \beta_n' A_{nk} + \gamma_n C_{nk} + \epsilon_{nk}$$

where the indices n and k denote the respondent and the alternative; α, β,

Commons Narrative

The origin of our food: Where do seeds come from?

Seeds are the basis for our food. Traditionally, seeds were a common good that was cultivated and developed by farmers over thousands of years. Today, seeds are increasingly privatized. New varieties are primarily developed and sold by a few powerful international agricultural corporations. Currently, only three corporations control over 60 percent of the global seed market.

These large corporations place patents and other intellectual property rights on new varieties and technologies. This makes seeds and varieties private property. Consequently, farmers must buy new seeds every year.

These seed companies work in a profit-oriented manner and focus on a few high-yielding varieties for industrial agriculture. This contributes to the loss of varietal diversity. However, diversity in our crops and varieties is essential for climate change adaptation. As a result of these developments, a very standardized range of fruit and vegetable varieties can be found in our stores.

Industry Narrative

The origin of our food: Where do seeds come from?

Seeds are the basis for our food. They have been cultivated and developed by farmers over thousands of years. Today, new varieties are primarily developed and sold by professional seed companies that use state-of-the-art technologies to produce high-quality seeds.

The development of new varieties is expensive. Seed companies protect varieties and technologies with patents and other property rights to cover development costs. These reward the companies' work and enable them to continuously develop new varieties, which is essential for adapting agricultural production to climate change.

The innovative breeding methods used by seed companies have significantly increased crop yields in recent decades. These efficiency gains make it possible to feed the growing world population. These companies are therefore making an important contribution to food security. As a result of these developments, a high-quality range of fruit and vegetable varieties can be found in our stores.

Fig. 3. Commons narrative (left) and industry narrative (right) that were used as information treatments (translated from German).

and γ are parameters to be estimated. ASC is an alternative-specific constant that indicates whether the alternative is the no-buy option (0) or not (1). The vector *A* stands for the dummy-coded attributes cultivation, origin, and ownership rights, and *C* is the price of the tomatoes. The parameters are respondent-specific, as indicated by the index *n*. In the random parameters logit framework, the parameters are assumed to be continuously and randomly distributed over respondents. Reformulating equation 1 transforms the model into willingness to pay space:

$$U_{nk} = \gamma_n * \left(\frac{\alpha_n}{\gamma_n} * ASC_k + \frac{\beta_n^{'}}{\gamma_n} * A_{nk} - C_{nk} \right) + \epsilon_{nk} = \gamma_n * \left(\rho_n * ASC_k + \delta_n^{'} * A_{nk} - C_{nk} \right) + \epsilon_{nk}$$

Where $\rho = \frac{\alpha_n}{\gamma_n}$ and $\delta_n^{'} = \frac{\beta_n}{\gamma_n}$ are marginal willingness to pay values. The parameters of equation 2 can be estimated with the maximum simulated likelihood estimation.

In our final model, we added two interaction terms. The first interaction term is the product of the ASC and a season split dummy (0 = summer, 1 = winter), which helps us to control for potential seasonal effects. A positive coefficient for this interaction would suggest that respondents are willing to pay more for a tomato in winter. The second interaction term is the product of the ownership attribute and a commons/open-source split dummy. It indicates whether framing the ownership attribute as commons or as open-source affects WTP values for the ownership attribute.

Equation 3 is the exact empirical equation that we used for estimation:

$$U_{nk} = -exp(\omega_n) * \left(\rho_{n0} * ASC_k + \rho_1 * ASC_k * winter_n + \delta_n^{'} * A_{nk} + \phi * Z_{nk} - C_{nk} \right) + \epsilon_{nk}$$

Whereas $\gamma_n := -exp(\omega_n)$ with ω_n being normally distributed. This leads to a log-normally distributed price parameter. Further $A_{nk} = (EUorganic,\ EUorganic+\ Bioverita,\ local,\ Germany,\ Spain,\ open-source/commons)$, i.e., the dummy coded attributes, and $Z_{nk} = open-source/commons * open-source\ vs.commons$, i.e., the interaction between the ownership attribute and the open-source and commons spilt sample.

4. Results

4.1. Discrete choice experiment

Table 4 presents the results from the random parameters logit model in WTP space estimated with the package Apollo 2.8 in R (Hess & Palma, 2019). The simulation of the log-likelihood was carried out with 1,500 Sobol draws, and covariances were numerically calculated. Reported standard errors are robust (clustered) standard errors. The reported estimated parameters are WTP values and indicate the additional WTP for the respective attribute level relative to the reference levels. For cultivation, the reference level is 'conventional', for origin 'Morocco', and for ownership 'private variety'. The parameters for the non-price attributes and the ASC are specified as random parameters with a normal distribution. The parameter for the price attribute is specified as log-normal. It is important to note that the estimated parameters are the location and scale parameters. These are not equal to the mean and standard deviation in the case of the log-normal distribution (Mariel et al., 2021). As the model is estimated in WTP space, the cost parameter is not relevant for interpreting WTP values. The ASC is coded 0 for the opt-out and 1 for both tomato alternatives. With such a coding, a positive parameter indicates utility increases from the purchase of tomatoes, with all attribute levels set to zero. The mean and the standard deviations of the non-cost attribute parameters indicate the average WTP and the heterogeneity of preferences. The two interaction terms (ASC with season and ownership with the commons/open-source split-sample) are specified as fixed parameters.

We first outline the results from the pooled model with all respondents (see Table 4, column two). Most estimated parameters of the model are statistically significantly different from zero. The ASC is the average WTP for 500 g of tomatoes if all attributes are set to the reference level (conventional production, grown in Morocco, private variety). It is EUR 2.53. For tomatoes grown locally, in Germany, and in Spain, the additional WTP is EUR 2.54, EUR 2.05, and EUR 0.63, respectively. If the tomatoes are certified with the EU Organic label, respondents are, on average, willing to pay a price premium of EUR 1.07. If the tomatoes also have the Bioverita certification, the additional WTP is EUR 1.42. If the tomato is from an open-source/commons variety, the additional WTP is EUR 0.43.

The interaction term with the open-source/commons split sample is

Table 2
Socio-demographic characteristics of the sample.

Variable	Respondents (n = 3147)	Population in Germany
Gender		
Female	53.1%	51.2%[a]
Male	46.1%	48.8%[a]
Other / no answer	0.8%	–
Mean Age	49.9	44.6[b]
Education		
No vocational qualification	8.3%	16.5%[c]
Currently in school or vocational training	6.9%	8.9%[c]
Vocational training	53.7%	47.5%[c]
Technical college degree, master craftsman	10.4%	8.9%[c]
Bachelor's degree	3.0%	2.5%[c]
Master's degree	14.4%	14.5%[c]
Doctoral degree	1.1%	1.2%[c]
Do not know / no answer	2.4%	–
Employment status		
Full-time employed (min. 35 Hours per week)	37.1%	50.4%[a]
Part-time employed (max. 34 h per week)	12.6%	
Pupil, student, trainee, federal volunteer, or conscript	8.6%	4.5%[a]
Retiree, pensioner	30.0%	21.7%[a]
Homemaker, or on parental or care leave	5.0%	3.5%[a]
Unemployed (job seeking)	3.7%	2.7%[a]
Permanently unable to work	1.6%	–
No answer / other	1.4%	–
Monthly income (net income, per household, in EUR)		
below 1,000	9.6%	9.6%[d]
1,000 – below 2,000	23.7%	26.1%[d]
2,000 – below 3,000	25.8%	23.5%[d]
3,000 – below 4,000	17.6%	16.1%[d]
4,000 – below 5,000	8.7%	10.3%[d]
> 5,000	5.9%	13.6%[d]
Do not know / no answer	8.6%	0.7%[d]
Average household size	2.2	2.0[e]
Place of residence		
Countryside or in a village (<10,000 inhabitants)	27.1%	25.5%[f]
Small town (10,000 inhabitants or more)	17.2%	15.0%[f]
Medium-sized town (25,000 inhabitants or more)	19.1%	27.5%[f]
City (100,000 inhabitants or more)	36.7%	32.0%[f]
Average share of groceries according to purchase location		
Supermarket	43.0%	–
Discounter	33.5%	
Farmers' market, farm store	12.4%	
Community-Supported Agriculture, subscription box	5.2%	
Organic store	3.5%	
Online	0.9%	
Homegrown	0.7%	
Other	0.8%	
Average share of organically certified vegetables purchased	32.8%	–
Average share of locally produced [up to 75 km] vegetables purchased	37.2%	–

Sources: [a]Census (2011); [b]Statista (2022); [c]Destatis (2019); [d]Destatis (2021); [e]Bundesinstitut für Bevölkerungsforschung (2019); [f]Statista (2020).

Table 3
Distribution of respondents across samples.

Sample and information treatment	Commons sample (n)	Open-source sample (n)	Total respondents (n)
No text	518	521	1039
Industry narrative	526	524	1050
Commons narrative	532	526	1058
Total respondents	1576	1571	3147

small and not statistically significant. There are hence no large differences in the WTP whether the attribute is labeled as a commons variety or as an open-source variety. Similarly, there is no statistical difference in WTP values between respondents who were told that they purchase tomatoes in summer compared to those that were told to purchase tomatoes in winter (ASCWinter).[2]

To investigate treatment effects, we estimated models for each information split sample separately (see Table 4, columns 3 to 5). As expected, the commons narrative positively affects WTP values for commons/open-source varieties. While the WTP is EUR 0.35 and EUR 0.36 in the no text and the industry narrative samples, it is EUR 0.59 in the commons narrative sample. This difference is statistically significant (z-test, $p = 0.014$ for commons narrative vs. industry narrative, $p = 0.009$ for commons narrative vs. no text). The commons narrative hence positively affects WTP for commons/open-source varieties, but the industry narrative does not affect consumers' WTP. Z-tests for all other attributes indicate no statistical difference between the information treatments, except for tomatoes grown in Germany, where the WTP is lower for respondents from the industry sample. We also estimated a pooled model with treatment interactions to test the treatment effects' robustness. This model, similar to the results from the z-test, indicates statistically significant differences in the WTP values for open-source/commons varieties between the commons narrative and the other two information treatments. The results of the z-test and the interaction model are presented in the Appendix (Tables A1 and A2). We further explored unobserved heterogeneity in several ways. First, we calculated conditional (individual) WTP values. Second, we estimated latent class models with two to six classes. Third, we estimated more random parameters logit models with different assumptions on the distributions. Although these results reveal further insights into unobserved heterogeneity, the models do not diverge strongly from the model presented here. All estimated models are presented in the online supplementary material.

Most respondents stated that they had enough information to make a good decision (87%), that they were sure about their decisions (79%), and that they found the decision scenario to be realistic (78%). <2% of respondents opted out in at least seven choice sets. The main reasons for opting out were high prices and unappealing options.

4.2. Survey

4.2.1. Familiarity with the concept and labels

About half of the respondents in the commons sample (49%) and 64% of respondents in the open-source sample stated they were completely unfamiliar with commons/open-source varieties before the survey and had never heard about them (see Table 5). Only 11% and 8%, respectively, claimed to be familiar with the term commons and open-source variety and its meaning. The Bioverita label was similarly unknown. We were hence correct to assume that respondents are mostly unfamiliar with open-source and commons varieties. This is especially relevant when interpreting the effects of information provision. To test whether familiarity is correlated with preferences, we estimate a mixed logit model interacting the respective attributes with the familiarity variables. Our analysis revealed a strong correlation between the two, which is not surprising as individuals who are unfamiliar with a concept are unlikely to consider it in a purchasing situation. This result suggests that our respondents made realistic choices reflective of real-life decision-making. However, we acknowledge that this model likely suffers from endogeneity. An unobserved factor may have caused both, preferences and familiarity, which can lead to a correlation between the error term and the familiarity variables, resulting in biased estimates. Therefore, we did not pursue this model further. The results of this analysis can be found in the online supplementary material.

[2] To further explore the potential effects of both season and tomato type, we estimated separate models for each season and tomato type. Our analysis found no significant differences between the split samples, indicating that season and tomato type did not significantly impact our results. Detailed results of these models can be found in the online supplementary material.

Table 4
Mixed logit model results.

	Full sample	No text	Commons narrative	Industry narrative
Means				
ASC	2.53 (0.12)***	2.51 (0.23)***	2.52 (0.21)***	2.47 (0.20)***
EU Organic	1.07 (0.05)***	1.18 (0.08)***	1.00 (0.08)***	1.03 (0.07)***
EU Organic + Bioverita	1.42 (0.05)***	1.49 (0.10)***	1.33 (0.09)***	1.44 (0.09)***
Local	2.54 (0.08)***	2.72 (0.15)***	2.45 (0.14)***	2.44 (0.13)***
Germany	2.05 (0.07)***	2.24 (0.12)***	2.04 (0.12)***	1.90 (0.10)***
Spain	0.63 (0.04)***	0.74 (0.07)***	0.60 (0.07)***	0.55 (0.06)***
Open-source/commons	0.43 (0.04)***	0.35 (0.06)***	0.59 (0.07)***	0.36 (0.07)***
Price	0.09 (0.03)**	0.04 (0.06)	0.10 (0.06)*	0.14 (0.05)**
Standard Deviations				
ASC	2.47 (0.08)***	2.61 (0.15)***	2.47 (0.13)***	2.32 (0.12)***
EU Organic	0.01 (0.05)	0.10 (0.12)	0.03 (0.08)	0.07 (0.09)
EU Organic + Bioverita	0.80 (0.05)***	0.79 (0.10)***	0.78 (0.09)***	0.81 (0.09)***
Local	1.32 (0.06)***	1.42 (0.10)***	1.26 (0.11)***	1.32 (0.10)***
Germany	0.77 (0.07)***	0.73 (0.11)***	0.79 (0.14)***	0.82 (0.11)***
Spain	0.65 (0.08)***	0.63 (0.12)***	0.56 (0.18)***	0.70 (0.13)***
Open-source/commons	0.48 (0.05)***	0.43 (0.12)***	0.60 (0.07)***	0.44 (0.15)**
Price	0.46 (0.04)***	0.44 (0.07)***	0.51 (0.07)***	0.43 (0.07)***
Interactions				
Ownership × Open-source vs. commons	−0.03 (0.05)	0.02 (0.08)	−0.09 (0.08)	−0.06 (0.08)
ASC × Winter	−0.03 (0.12)	0.11 (0.24)	−0.45 (0.19)**	0.31 (0.21)
Number of Choices	28,323	9,351	9,522	9,450
Number of Respondents	3,147	1,039	1,058	1,050
Log Likelihood (Null)	−31,116.00	−10,273.12	−10,460.99	−10,381.89
Log Likelihood (Converged)	−20,277.28	−6,704.88	−6,871.38	−6,682.46

***p < 0.001; **p < 0.01; *p < 0.05 Standard errors in brackets.

4.2.2. Self-stated purchase criteria for fresh tomatoes

The most important self-stated purchase criteria for fresh tomatoes were the search and experience attributes good taste, the right degree of ripeness, and good smell (see Table 6). Aspects related to seed production and breeding received comparatively low importance ratings. Whether tomato varieties are bred organically, are reproducible, or are old/traditional was rated as less important than most other aspects. That tomatoes stem from a commons/open-source variety was rated even less important. A low price was of medium importance but more important than any of the aspects related to seed production and breeding.

Seasonality was significantly more important for respondents who were told to imagine purchasing tomatoes in summer (M = 3.77, SD = 1.04) compared to those who were told to imagine purchasing tomatoes in winter (M = 3.62, SD = 1.05; t(3110) = 4.05, p = 0.000***). Other differences between the split samples could not be observed.

4.2.3. Attitudes

Table 7 provides an overview of the agreement with various statements. Respondents most strongly agreed with the statement that farmers should breed their own vegetable varieties and not be dependent on industrially bred varieties and the statement that seeds should be free for everyone to use. They least agreed with the statement that patents and other property rights are necessary to ensure progress in plant breeding. The information treatments had an effect, and there were significant differences for the statements that relate to variety and seed ownership. Except for the statement on patents, respondents from the commons narrative sample agreed more with all statements related to seed production and breeding. These results contextualize the quantitative results from section 4.1. in that they provide insights into respondents underlying beliefs which likely influence their WTP for commons/open-source varieties.

Table 5
Familiarity with concepts.

Familiarity with concepts/labels	M	SD
EU Organic Certification	2.32	0.68
Commons variety (sample b)	1.61	0.68
Open-source variety (sample a)	1.43	0.64
Bioverita Certification	1.41	0.63

Note. Means (m) and standard deviations (sd) whereby 1 = unfamiliar, 2 = heard it about it but unsure what it stands for, 3 = familiar with the term/label and its meaning; 'do not know' responses were excluded.

5. Discussion

We observed a relatively small but significant WTP for commons/open-source varieties. This indicates that consumers generally prefer commons/open-source varieties over private varieties (hypothesis 1: confirmed). This may partially be explained by respondents' strong preference for farmer-led, independent seed production (see Table 7). As expected, WTP values for commons/open-source varieties were smaller than for other sustainability-related credence attributes, such as regional production and organic cultivation and breeding (hypothesis 2: confirmed). This finding aligns with previous research on preferences for local and organic production, as outlined in section 2.2. The observed WTP values for commons/open-source varieties are comparable to the self-stated WTP values obtained by Kliem and Wolter (2022). Noticeably, they are smaller than the WTP values for tomatoes from Spain rather than Morocco. The fact that the WTP values for

Table 6
Self-stated importance of various attributes in purchase decisions.

When buying fresh tomatoes, how important is it to you that the tomatoes …	M	SD
… taste good?	4.71	0.55
… have the right degree of ripeness?	4.20	0.75
… smell good?	3.95	0.93
… are not wrapped in plastic?	3.85	1.11
… are flawless and fresh?	3.78	1.05
… were grown in Germany?	3.73	1.04
… are in season?	3.69	1.05
… are cheap?	3.66	1.01
… were grown in your region (up to 75 km)?	3.60	1.07
… were grown under organic conditions?	3.58	1.07
… are from organically bred varieties?	3.45	1.08
… are reproducible?	3.30	1.15
… are from a traditional, old variety?	3.17	1.15
… are from an open-source/commons variety?	3.12	1.06
… have a special or unusual shape or size?	2.46	1.13
… have a special or unusual color?	2.46	1.18

Note. Means (m) and standard deviations (sd) whereby 1 = not at all important, 5 = very important; 'do not know' responses were excluded.

Table 7
Agreement with statements by type of information treatment.

Statement	Full sample	No text (n)	Commons narrative (c)	Industry narrative (i)
Farmers should breed their own vegetable varieties and not be dependent on industrially bred varieties.*	4.28	4.25 c	4.37 n, i	4.21 c
Seeds should be for everyone to use.*	4.18	4.17 c	4.27 n, i	4.09 c
When I buy a vegetable, I want to know if it is a genetically modified variety or not.*	4.17	4.15	4.17	4.18
Vegetables do not necessarily have to look pretty; above all, they must be tasty.*	4.16	4.13	4.18	4.16
Plant varieties should not be the private property of companies.	4.14	4.12 c	4.27 n, i	4.03 c
The multiplication of seeds should again be in the hands of farmers and not in the hands of a few large multinational firms.*	4.11	4.09 c	4.25 n, i	3.99 c
Diversity of life (=biodiversity) is important.*	4.05	4.0 c	4.14 n, i	4.01 c
I want to be able to buy traditional and old vegetable varieties.*	4.04	4.01	4.06	4.05
More diversity on the plate means more diversity of life (=biodiversity).*	3.99	3.94 c	4.06 n	3.96
I want to be able to buy organically bred varieties.*	3.87	3.84	3.91	3.86
In the past vegetables used to be much tastier.*	3.86	3.90	3.88	3.82
The offer of vegetables is generally very limited and highly standardized.*	3.82	3.80 s	3.91 n, i	3.76 s
When I buy a vegetable, I want to know if it is an industrial variety or not.*	3.74	3.71	3.80	3.72
Within a vegetable category (e.g., tomatoes or carrots) I want to be able to choose among different varieties that differ with respect to color, shape, taste, etc.*	3.70	3.66 s	3.75 n	3.68
Patents and other property rights are necessary to ensure progress in plant breeding.	3.09	3.11 i, s	2.91 n, i	3.25 n, s

Note. Averages whereby 1 = strongly disagree, 5 = strongly agree; 'do not know' responses were excluded. Statistically significant differences between the samples are indicated through the letter of the sample(s) to which a difference could be observed. Appendix Fig. A1 compares this data to data from Meier and Oehen (2019), who used the same statements in Switzerland, Spain, France, and Italy. * Statements that were used by Meier and Oehen (2019).

commons/open-source varieties are comparatively small may have several reasons: (1) Given the complexity of the topic and the novelty of the concept, the social and environmental advantages of commons/open-source varieties may not be immediately apparent to consumers, who were largely unfamiliar with the concept, as illustrated in section 4.2. Studies show that if consumers are uncertain about the sustainability effects of an attribute, they are not willing to pay significant price premiums for it (Herrmann et al., 2022). (2) Consumers may perceive the personal relevance of commons/open-source varieties to be relatively low. Most consumers do not have a personal connection to breeding and seed production, and although they may have a favorable attitude towards commons/open-source produce, personal preferences for health, safety, and quality aspects may outweigh these considerations (c.f. Wirth, Stanton & Wiley, 2011). Regional and organic products are often associated with high quality, good taste, and health benefits (only organic) that have immediate relevance to consumers (Hempel & Hamm, 2016a; Hughner et al., 2007; Moser, 2016; Rana & Paul, 2020; Schäufele & Hamm, 2017). It remains unclear if consumers also associate commons/open-source produce with these qualities, but research by Kliem and Wolter (2022) suggests that this may not be the case. (3) Similarly, other purchase factors, especially experience attributes, may simply be more important to consumers. The self-stated importance of attributes affecting purchase decisions (see Table 6) showed that participants find the experience attributes good taste, the right degree of ripeness, good smell, flawlessness, and freshness to be much more relevant to their purchasing decisions than credence attributes relating to seed production and breeding. No experience attributes were included in the discrete choice experiment. Instead, respondents were requested to assume that the available tomatoes are equal in quality and taste. The non-inclusion of experience attributes in the discrete choice experiment can be seen as a limitation of the study. Nevertheless, the fact that the self-stated attitude ratings are in line with the results from the discrete choice experiment (stronger preferences for local and organic production and -breeding than for commons/open-source varieties) provides additional validity to our findings and demonstrates the overall low relevance of this attribute in consumers' purchase decisions.

There is no meaningful difference in WTP values regarding the terminology used (hypothesis 3: not confirmed). The different framings as 'commons varieties' and as 'open-source varieties' elicited WTP values that statistically do not differ. Hence, no recommendations can be made regarding the term to be used for marketing these varieties. In contrast, the narrative (commons vs. industry narrative) affected WTP values. Providing additional information on the relevance of commons/open-source varieties positively affected WTP values for these varieties. Given that respondents were largely unfamiliar with commons/open-source varieties (see Table 5), our findings support the observation that information effects are to be expected for foods and certifications which are unfamiliar to respondents (Emberger-Klein & Menrad, 2018; Lombardi et al., 2019; Sogari et al., 2022). The information treatment also affected participants' agreement with various statements (see Table 7). Respondents who received the commons narrative were significantly more likely to agree with statements supporting commons-based seed production and breeding.

Previous literature discusses various explanations for information effects. They include a rational reflection on the information provided, leading to changes in the perceived marginal utility and the use of availability heuristics which may lead to the assignment of greater importance to attributes for which more information was provided (Hoevenagel & van der Linden, 1993; Munro & Hanley, 2001). Directional contextual effects caused by the survey design (e.g., the order in which information is provided) or effects of the perceived credibility of the valuation scenario (e.g., the extent to which respondents find the description of the status quo to be plausible) can also influence WTP values (Moore, 2002; Welling et al., 2022). Contrary to our expectations, providing information highlighting the advantages of private varieties did not negatively affect consumers' WTP for commons/open-source varieties compared to respondents who received no additional information (hypothesis 4: partially confirmed). These findings demonstrate that educating consumers about the relevance of commons-based breeding and seed production can increase their WTP values for commons/open-source varieties and could hence contribute to generating demand for these varieties. Connecting commons narratives to qualities that are likely of personal relevance (e.g., high quality or taste) may further increase the effect of information provision (c.f. Ajzen, Brown & Rosenthal, 1996).

At the same time, it is worth discussing whether the focus should really be placed on consumer information and transparency. Commons/open-source varieties as a new credence attribute can enable consumers to express their preferences regarding variety ownership and seed production. This presupposes that these qualities are made transparent, e.g., through a label or certification on the packaging or product tag. However, the complexity of the topic, the relatively low WTP values, and the large amount of already available sustainability-related labels, which make it difficult for consumers to keep track of the different standards, raise the question if the introduction of yet another label and certification is worth the effort and economically feasible. It should also be noted that real-life settings can lead to significantly lower WTP values than

hypothetical choice experiments (Sanjuán-López & Resano-Ezcaray, 2020). Integrating commons/open-source varieties into existing, well-established certification schemes that are already known to consumers might hence be more sensible (Kliem & Wolter, 2022).

Furthermore, thought must be given to how consumers' willingness-to-pay premiums can be translated into financing models for commons/open-source varieties. Since traditional income sources such as royalties from intellectual property rights and reseeding fees are not applicable and are insufficient in volume in the first place, new ways of financing must be found to ensure the continuous development of varieties. So far, the financing of commons/open-source varieties largely relies on donations from private and charitable foundations, and long-term funding is often precarious (Kotschi et al., 2022). Kotschi et al. (2022) hence propose several ways to finance commons/open-source varieties. They include (1) the introduction of a label, which is associated with certification and use fees that could partially be invested in breeding. If such a label were to be introduced, it would require a trustworthy, independent non-profit organization to develop standards and manage the certification process. (2) Cross-sector pooling strategies, for example, through alliances between retailers and breeders, where a certain percentage of the net sale of retailers is invested in breeding. First voluntary cross-sector initiatives have trialed such approaches, e.g., the FAIR-BREEDING Initiative. (3) Community-based plant breeding, where breeding activities are financed through producer associations, similar to community-based agriculture schemes. And (4) breeding on demand, where one or several companies (e.g., retailers) commission the development of a variety with traits specifically tailored to their needs. To secure the long-term financing of commons/open-source varieties, a combination of these consumer- and market-oriented strategies and public funding will be necessary to ensure the continuous development of locally-adapted varieties.

6. Conclusion

Crop genetic diversity is the basis for diversified agricultural systems, which are essential for climate change adaptation and the long-term resilience of our food systems. Common ownership of seeds and varieties can play a central role in supporting the development of diversified agricultural systems. With the first commons/open-source varieties entering consumer markets, consumer preferences and WTP for these varieties are worth exploring.

Our research shows that consumers prefer commons/open-source varieties to private, company-owned varieties and are willing to pay a price premium for these varieties. However, the premium they are willing to pay is smaller than for locally grown and organic produce. Furthermore, these sustainability-related credence attributes likely only play a minor role in the overall purchase criteria for many consumers. Experience attributes such as taste, ripeness, and smell are likely of higher relevance for purchase decisions of fresh tomatoes, and consumers may pay only limited attention to credence attributes that are of relatively low personal relevance. Providing consumers with information highlighting the advantages of commons/open-source varieties increases consumers' WTP, while information highlighting the advantages of private varieties does not affect WTP values for commons/open-source varieties.

6.1. Policy implications

Our study makes a valuable contribution to several important food policy discourses, particularly in relation to agrobiodiversity preservation and enhancement. It highlights the potential for commons/open-source varieties as a new credence attribute that enables consumers to actively support the long-term safeguarding of agrobiodiversity and contribute to more sustainable and resilient food systems. This aligns with current policy discussions on the role of consumers in promoting sustainable food systems, which emphasize the potential for consumers to drive change through their purchasing decisions. It also connects to discourses on seed sovereignty since it suggests that empowering consumers to choose commons/open-source varieties can help to diversify and decentralize seed systems. However, our findings also reveal that the steering effect of consumer choices is limited due to the comparatively low WTP values we observed. This underscores the need for a larger policy framework that supports the establishment of commons/open-source varieties as a viable and sustainable alternative to company-owned varieties. It hence points to the critical role of government intervention in fostering a social-ecological transformation of the seed sector.

In this context, introducing a publicly-funded commons/open-source label or including commons/open-source varieties in existing certification standards may serve as one of several measures to support the preservation and enhancement of genetic diversity. However, additional measures are needed to fully establish commons/open-source varieties as a sustainable alternative to company-owned varieties. Specifically, the establishment of commons/open-source standards for varieties bred with public funding, the introduction of legal requirements for retailers to invest part of their net sale or revenue into commons/open-source breeding, and the easing of variety registration guidelines for commons/open-source varieties could serve as initial steps towards supporting their upscaling. These measures must be developed in cooperation with stakeholders along the entire value chain. This aligns with policy discourses on the need for multi-stakeholder collaboration in promoting sustainable food systems, emphasizing the importance of partnerships between government, industry, and civil society to drive change.

In addition, our findings highlight the need for increased awareness and education among consumers, policymakers, and industry stakeholders about the importance of agrobiodiversity conservation and the role that commons/open-source varieties can play in achieving this goal.

Funding additional research in this area will also be crucial. We propose three future research directions: (1) Carrying out real-life experiments that include selling open-source food products that are clearly labeled as such. (2) Exploring the potential to integrate open-source/commons varieties in existing labels and certification schemes such as the EU organic standard. And (3) trailing and evaluating financing strategies for commons/open-source varieties that include the entire value chain.

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CRediT authorship contribution statement

Lea Kliem: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Julian Sagebiel:** Methodology, Formal analysis, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

See Tables A1 and A2 and Fig. A1.

Table A1
P-values from z-Tests between coefficients from mixed logit models.

	Commons × industry narrative	Commons narrative × no text	No texts × industry narrative
Means			
ASC	0.848	0.968	0.885
EU Organic	0.794	0.103	0.153
EU Organic + Bioverita	0.391	0.224	0.684
Local	0.943	0.189	0.156
Germany	0.355	0.247	0.031
Spain	0.606	0.151	0.044
Open-source/commons	0.014	0.009	0.887
Price	0.605	0.456	0.198
Standard Deviations			
ASC	0.389	0.472	0.120
EU Organic	0.400	0.364	0.842
EU Organic + Bioverita	0.850	0.980	0.878
Local	0.700	0.286	0.466
Germany	0.867	0.731	0.565
Spain	0.526	0.779	0.661
Open-source/commons	0.342	0.237	0.953
Price	0.428	0.488	0.915
Interactions			
Ownership × Open-source vs. commons	0.812	0.382	0.512
ASC × Winter	0.006	0.065	0.531

Table A2
Results from WTP-space mixed logit model with interactions of information treatments.

	Effects of no treatment		Interaction effects	
	Mean	Standard deviation	Commons narrative	Industry narrative
ASC	2.50 (0.16)***	2.44 (0.08)***	−0.20 (0.21)	0.26 (0.21)
EU Organic	1.16 (0.07)***	0.00 (0.08)	−0.16 (0.09)*	−0.11 (0.09)
EU Organic + Bioverita	1.46 (0.08)***	0.79 (0.05)***	−0.11 (0.10)	0.01 (0.10)
Local	2.65 (0.12)***	1.31 (0.06)***	−0.17 (0.15)	−0.22 (0.15)
Germany	2.20 (0.10)***	0.75 (0.07)***	−0.14 (0.13)	−0.29 (0.13)**
Spain	0.72 (0.06)***	0.66 (0.07)***	−0.12 (0.09)	−0.16 (0.09)*
Open-source/commons	0.35 (0.05)***	0.51 (0.06)***	0.20 (0.07)**	−0.01 (0.07)
Price	0.08 (0.03)**	0.45 (0.04)***		
Number of Choices	28,323			
Number of Respondents	3147			
Log Likelihood (Null)	−31116.00			
Log Likelihood (Converged)	−20271.71			

***p < 0.001; **p < 0.01; *p < 0.05 Standard Errors in Brackets.

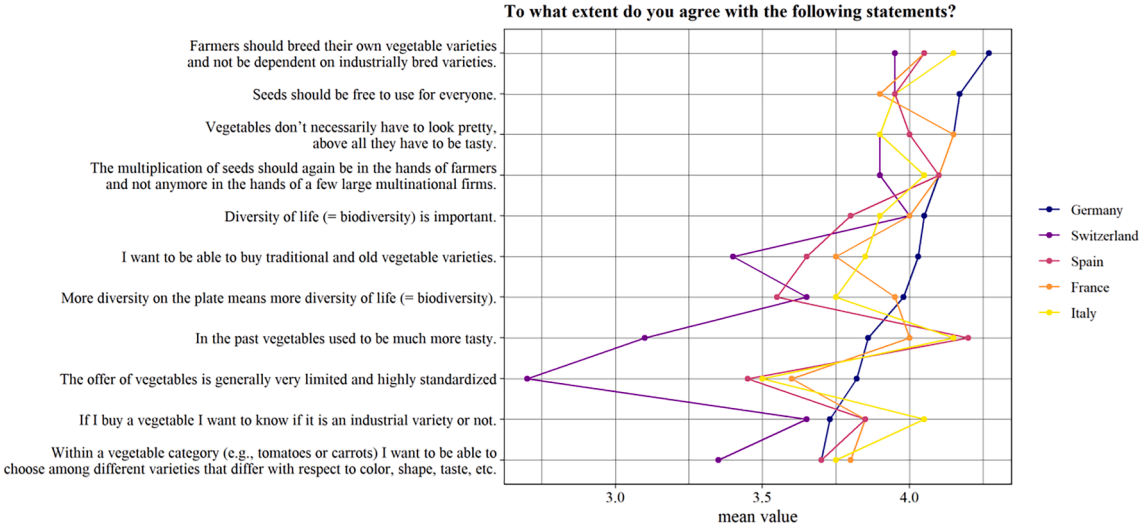

Fig. A1. Agreement with statements in comparison to other European countries. Averages, whereby 1 = strongly disagree, 5 = strongly agree; 'do not know' responses were excluded. The data from Switzerland, Spain, France, and Italy was collected by Meier and Oehen (2019). Sample sizes were 496–566 respondents The response scale from Meier and Oehen was adjusted to enable comparison.

Supplementary material

Supplementary material to this article can be found online at Github. The supplementary material includes several other estimated models and is available as an HTML file. Further, the GitHub repository includes the raw data file and the complete code used to generate the models and the HTML file. Our research is fully reproducible, and we encourage readers to utilize the provided code to verify our models and expand upon our analysis.

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