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**Article — Published Version**

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Business Strategy and the Environment

**Provided in Cooperation with:**

John Wiley & Sons

*Suggested Citation:* Schulze, Maureen; Jürkenbeck, Kristin (2024) : The Symbiotic Production of Food and Green Electricity: Consumer Preferences for Food Produced in Agrivoltaic Systems, Business Strategy and the Environment, ISSN 1099-0836, Wiley, Hoboken, NJ, Vol. 34, Iss. 2, pp. 2088-2102, <https://doi.org/10.1002/bse.4080>

This Version is available at:

<https://hdl.handle.net/10419/319302>

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## RESEARCH ARTICLE OPEN ACCESS

# The Symbiotic Production of Food and Green Electricity: Consumer Preferences for Food Produced in Agrivoltaic Systems

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**Received:** 29 February 2024 | **Revised:** 8 October 2024 | **Accepted:** 14 November 2024

**Funding:** We acknowledge support by the Open Access Publication Funds of the Göttingen University.

**Keywords:** agrivoltaic systems | consumer preferences | food | renewable energies

## ABSTRACT

In light of the commitment by EU member states to achieve climate neutrality for the European continent by 2050, the expansion of renewable energy sources emerges as a significant challenge of our time. Agrivoltaic systems, which combine the production of renewable energy and food, offer a solution to alleviate the competition for limited land resources. However, scientific insights into whether consumers value food produced in agrivoltaic systems are lacking, so far. Knowledge of consumers' preferences is, however, crucial to successfully commercialize food production within agrivoltaic systems. This study addresses this research gap by conducting a hypothetical choice experiment with a sample of 448 German consumers. It examines consumers' preferences for food produced in agrivoltaic systems, using raspberries as a case study. Results of the random parameter logit (RPL) modeling revealed that consumers are willing to pay a premium for food labeled with information about the production of green electricity. Additionally, information on reduced plastic and water usage of food produced within agrivoltaic systems were also valued, next to domestic and regional production. A latent class segmentation was carried out for the targeted marketing for food produced in agrivoltaic systems. This resulted in four distinct consumer segments that differ according to their preference structure. Targeted recommendations are provided to enhance consumer acceptance and facilitate the diffusion of agrivoltaic systems.

## 1 | Introduction

The shift toward renewable energy sources, which aims to address global energy demands while simultaneously replacing fossil fuels—a major driver of climate change—stands out as a significant socio-political challenge in our time (European Commission 2019). The expansion of most renewable energy sources requires large areas of land, which are also needed to face the growing challenge of food security due to the impacts of climate change and a growing world population. To

alleviate the competition for limited land resources, the implementation of agrivoltaic systems has been suggested. In agrivoltaic systems, photovoltaic panels are mounted above the ground, facilitating food production such as grain, fruit, and vegetable crops underneath while simultaneously generating solar electricity above (ISE 2022), thus offering promising synergy effects (Weselek et al. 2019). With a capacity increase from 2.9 gigawatts (GW) in 2018 to over 14 GW in 2020 worldwide, the installation of agrivoltaic systems has also experienced exponential growth but only accounts for a small share

[Correction added on 20 December 2024, after first online publication: The Funding section has been updated in this version.]

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of solar energy so far (ISE 2022). Although agrivoltaic systems offer several benefits, scientific insights into whether consumers value food produced in agrivoltaic systems is lacking, so far. Knowledge on consumers' preferences is, however, crucial to successfully commercialize food production within agrivoltaic systems.

A steadily growing group of consumers is increasingly interested in how the food they consume is produced. For these consumers, a sustainable food production process that neither harms the environment nor human health is of particular importance (Bangsa and Schlegelmilch 2020). Meat and dairy with higher animal welfare requirements (Ammann et al. 2024) or locally/regionally produced food (Bannor and Abele 2021) are just two examples of consumers' increasing interest in how the food they eat is produced. Because consumers cannot experience, neither before nor after consumption, whether the product is produced sustainably or not, additional front-of-package information is needed (Schulze, Spiller, and Risius 2021). The food industry has already been reacting to consumers changed preferences providing consumers with additional information on sustainability or health-related information (e.g., labels, health claims).

The dual use of agricultural land to simultaneously produce food and solar electricity offers various benefits for crop cultivation that has the potential to serve consumers' increasing interest in environmentally friendly produced food products and health-benefits. Because the solar modules offer sun protection for plants, which in turn prevents excessive heating (Marrou et al. 2013) agrivoltaic systems are characterized by improved water use efficiency (Elamri et al. 2018; Marrou et al. 2013). It is widely acknowledged that consumers value information on the environmental impact of the food production process (Bangsa and Schlegelmilch 2020) and the few studies that specifically investigated consumers' preferences for water usage in food production suggest a strong consumer interest in information about water usage in food production (Peschel et al. 2016). Another benefit of agrivoltaic systems, in terms of sustainability is, that the production systems offer benefits in terms of reduced plastic usage in fruit production (Weselek et al. 2019). Especially in fruit production, sheltering of plants is necessary to protect plants from frost and hail (Gandorfer, Hartwich, and Bitsch 2016). For this purpose, in traditional farming, plants are covered with anti-hail nets made of plastic. Cultivation of plants under solar modules makes this redundant. This reduced usage of plastic in the production process of food produced in agrivoltaic systems has the potential to serve consumers with an interest in environmental protection. Research on food packaging has already shown that some consumers prefer environmentally friendly food packaging (Macht, Klink-Lehmann, and Venghaus 2023).

Next to environmental sustainability, health is another important purchase motive for food (Raaijmakers et al. 2018). Food produced in agrivoltaic systems can offer consumers health-related product characteristics. As such, sheltering plants by solar modules protect plants from fungal diseases following extended rainfall (Toledo and Scognamiglio 2021; Weselek et al. 2019; Sinha et al. 2018). This in turn allows farmers to reduce the usage of pesticides. Studies by Koch et al. (2017) and Simoglou

and Roditakis (2022) identified that consumers perceive pesticide residues in food products as major risks to human health.

However, although food production in agrivoltaic systems offers various environmental sustainability and health-related benefits, the evaluation of agrivoltaic systems presumably confronts consumers with conflicting preferences. It is widely acknowledged that consumers usually tend to initially reject novel food technologies and unfamiliar foods. In contrast to many other domains, novel technologies in the food sector are predominantly perceived as negative by consumers. Novel food production methods often suffer from being perceived as unnatural (Siegrist and Hartmann 2020). Food produced in agrivoltaic systems thus confronts consumers with the conflicting preferences of a general interest in sustainable food production and skepticism toward novel food production technologies. How consumers react to this interplay of conflicting preferences and whether they value the simultaneous production of food and solar energy on the same land is unknown so far.

This study tries to close this research gap investigating consumers' preferences for raspberries from agrivoltaic systems. Raspberries were chosen as a product example because they are a frequently consumed berry in Germany. In total 64.9 kg of fresh fruit, including 5.1 kg of berries and approximately 1 kg of raspberries per inhabitant was consumed in 2022/2023 (Bundesanstalt für Landwirtschaft und Ernährung 2021). Because raspberries available in German supermarkets are among the fruits that are most frequently contaminated with pesticides (Bundesamt für Verbraucherschutz und Lebensmittelsicherheit 2023), production in agrivoltaic systems offers great potential. Due to the plant's high sensitivity to weather effects, the cultivation of raspberries is highly dependent on sheltering, which again offers great potential for production in agrivoltaic systems (Destatis 2023). Additionally, agrivoltaic raspberry production on a larger scale is gaining increasing interest among farmers in Europe (Lohrer n.d.), and thus, it can be expected that raspberries cultivated under solar modules will be available in supermarkets in the near future. Therefore, to successfully market raspberries from agrivoltaic systems, consumers' willingness to pay (WTP) a price premium is crucial.

An online survey, including a discrete choice experiment was conducted with German consumers. The paper is organized as follows: Section 2 provides an overview of the previous scientific results and theoretical background of consumer preferences for sustainably produced food with a special focus on preferences for fruits. Section 3 describes the methodological approach by explaining in detail how (1) the overall preference structure for raspberries produced within agrivoltaic systems was assessed and (2) the segmentation approach to account for differences according to consumers' preferences for product attributes associated with raspberries produced in agrivoltaic systems was applied. Section 4 provides the reader with the results of the study, followed by Section 5 where results are discussed and related to previous research. In Section 6, recommendations regarding the market potential, as well as marketing recommendations for food products produced within agrivoltaic systems, are derived. The article ends with Section 7 highlighting limitations and future research.

## 2 | Theoretical Overview

Raspberry production in agrivoltaic systems holds great potential to provide food with climate and environmental benefits—food product characteristics that are valued by a growing group of consumers (Schulze, Spiller, and Jürkenbeck 2022). However, research on consumers' preferences for raspberries in particular is scarce. Previous studies on consumers' buying motives for different kinds of fruits showed that consumers value characteristics such as freshness (Péneau et al. 2006), taste and visual appearance (Hueppe and Zander 2024), as well as packaging (Koutsimanis et al. 2012) and geographical origin (Segovia and Palma 2016).

In the decision-making process, consumers need to rely on product attributes to evaluate the quality of a product. Usually, consumers rely on search, experience, and credence attributes (Darby and Karni 1973). Search attributes, such as price, can be evaluated pre-purchase, experience attributes, such as taste, after purchase, and credence attributes, such as the environmental impact of foods, can be assessed neither pre-purchase nor post-purchase. Consumer's increasing interest in sustainable food production processes has thus enhanced the importance of credence attributes. Consumers value information on the production method, such as organic certification (Rahman and Nguyen-Viet 2023) or fair trade (Fuller and Grebitus 2023; Iweala et al. 2022). Tait, Saunders, and Guenther (2015) highlighted that UK consumers appreciate increased water use efficiency when evaluating the fruit production process. Another study by Oh, Herrnstadt, and Howard (2015) also found evidence for consumers' interest in sustainable production methods by revealing a higher WTP for local production and natural bird pest management in apple and grape production. More recent studies, for example, from Mazzocchi, Ruggeri, and Corsi (2019) or Di Vita et al. (2021) also pointed to consumers' preferences for sustainable fruit production processes.

As known from research on other food categories, sustainability-related information on the production process of foods matters to an increasing subgroup of the population, yet not the whole population (Raaijmakers et al. 2018). To thoroughly understand these heterogeneous consumer preferences, as well as to estimate the market potential of food produced in agrivoltaic systems, it is beneficial to classify consumers into homogeneous groups based on their preferences, a method that has been widely applied previously in food marketing research (Jürkenbeck, von Steimker, and Spiller 2024; Risius, Hamm, and Janssen 2019).

The same applies to consumers' reluctance toward new food technologies and production methods, as some individuals value sustainable food characteristics and technologies more than others (Piracci et al. 2023; Siegrist and Hartmann 2020). However, most consumers usually have scarce knowledge about how their food is produced (Connor and Siegrist 2010). Consumers' opinions about the production process of food are rarely based on elaborate information processing. To compensate for the lack of profound knowledge, consumers tend to rely on heuristics to facilitate the decision-making process or process of opinion formation (Siegrist and Hartmann 2020). One widely acknowledged heuristic to evaluate the quality of food is that consumers overestimate the value of naturalness. The so-called natural-is-better

heuristic leads to consumers' assumption that natural foods (e.g., foods that are produced with [rarely] no human interference) (Siegrist and Hartmann 2020) are perceived as healthier and tastier, and the production process as more sustainable (Román, Sánchez-Siles, and Siegrist 2017). Reluctance toward human intervention in the food production process has been shown in various sectors along the food supply chain, such as novel food technologies applied in the production process (e.g., gene technology) (Scott et al. 2018) or perception of using novel technologies in housing and handling of livestock (e.g., robots in dairy farming) (Langer and Köhl 2024). Whether the beneficial characteristics of food production in agrivoltaic systems overcome consumer reluctance toward novel food production processes still needs to be investigated.

The simultaneous production of green electricity on the same land as food is one core sustainability benefit. It remains, however, an open question whether consumers value front-of-packaging information on the production of green electricity in the food production process. Previous research, though not in the food domain, showed that consumers are generally open to green energy. Rogers et al. (2008), Liu, Wang, and Mol (2013), and Vuichard, Stauch, and Wüstenhagen (2021) showed that wind and solar energy are mostly accepted. Similarly, recent polls from 2023 showed that a large share of European consumers supports the development of renewable energy sources, especially the expansion of solar energy (Tesvolt 2023; European Union 2023). However, the implementation of large solar parks is often accompanied by landscape changes and therefore has a visual effect on landscape quality—a consequence of solar energy production that is less accepted by the public (Cousse 2021).

## 3 | Materials and Methods

### 3.1 | Data Collection and Questionnaire Structure

Data were collected by means of a structured online questionnaire that was available to German consumers between September 19 and 26, 2023. Data collection was supported by the online access panel provider Bilendi GmbH, Berlin, Germany. The questionnaire was structured as follows: After a short introduction, participants were asked to indicate quota-relevant sociodemographic characteristics, followed by questions regarding their shopping behavior for food in general. Subsequently, participants were presented with an informational text that briefly explained the concept of agrivoltaic systems (Appendix A). Given the early adoption stage of agrivoltaic systems and the limited empirical data on consumer acceptance of food produced in such systems, it is reasonable to assume that consumers require additional information on what food production in agrivoltaic systems entails. This was especially important to ensure participants understood the product characteristics related to the production process. However, this experimental design must be considered when interpreting the results and deriving recommendations (e.g., emphasizing the importance of educating consumers to foster acceptance of sustainably produced food products). The informational text was developed together with an expert from the field of agrivoltaics and subsequently discussed among researchers within the field of food marketing to guarantee

neutrality (see Appendix A). This was followed by the discrete choice experiment, where respondents were confronted with hypothetical choice situations on raspberries. Because discrete choice experiments are of hypothetical nature, a cheap talk script was included directly before participants were confronted with the choice tasks. The cheap talk script is a widely applied approach to reduce biases by making participants aware of the importance to answer as honestly and realistically as possible (Lusk 2003). The questionnaire closed with questions regarding participants' awareness of different sustainability dimensions.

To check participants' attention, two explicitly instructed response items (e.g., "To check for your continuous attention, please select 'agree'") were included to ensure high data quality. Participants who incorrectly responded to those items were directly excluded and not allowed to finish the survey. Another  $n=24$  respondents were excluded due to rapid response behavior (faster than 1/3 of the overall median). Additionally, we controlled for careless response behavior by excluding participants who chose the same option in more than 90% of questions ( $n=20$ ). From the remaining ( $n=528$ ) participants,  $n=80$  participants stated to never buy raspberries and were therefore excluded from the sample. Finally,  $n=448$  participants were included in the final sample. Table 1 provides a detailed overview of the sociodemographic sample characteristics.

### 3.2 | Choice Experiment Method

Choice experiments are based on two influential theories of consumer behavior, namely, Lancasters' theory of consumer behavior (Lancaster 1966) and random utility theory (McFadden 1986). The former assumes that a consumer obtains utility from a product's different characteristics and not just the product itself (Lancaster 1966). The latter assumes that an individual, when provided with different alternatives, would choose the product

that provides the highest utility, and that consumers' utility has also a random component to account for unobserved influences (e.g., subjective taste and psychological factors) (McFadden 1986; Chinedu et al. 2018). Choice experiments have been widely applied to elicit consumer preferences for sustainable food product attributes (e.g., Fuller and Grebitus 2023; Sonntag et al. 2023).

As such, choice experiments provide participants with different choice sets, each consisting of different products with different product attributes. Participants are then asked to choose their preferred product as they would in a supermarket. Including a no-buy alternative, and thus giving participants the option to choose no product at all, is beneficial because it reduces biases (Dhar and Simonson 2003). First, a random parameter logit model was applied to assess an initial overview of the overall preference structure. Second, latent class conditional logit modeling was applied to identify different consumer segments. The approach allows for the integration of a discrete representation of unobserved heterogeneity among individuals (Yoo 2020).

The choice experiment included six different attributes describing potential product characteristics from raspberries cultivated conventionally and in agrivoltaic systems. Additionally, the product price was included. Table 2 provides an overview of the attributes and their corresponding levels considered in the experiment. Because the production of green electricity is a crucial benefit of agrivoltaic systems, the attribute "production of green electricity" was included with three different levels: "with production of green electricity," "without production of green electricity," and "no information" regarding energy production. Additionally, as already described earlier, food production in agrivoltaic systems offer benefits in terms of increased water use efficiency, reduced usage of plastic, and pesticides. Those attributes were therefore included in the choice attributes, each with three varying levels (i.e., reduced usage, usual usage, and no information). Given prior research indicating that the origin of a product

TABLE 1 | Sample description.

	Total sample (%) $n = 448$	German population <sup>a</sup> (%)
Gender		
Male	50.4	48.9
Female	49.6	51.1
Age		
16–29 years	17.6	18.1
30–39 years	16.5	15.2
40–49 years	15.8	14.5
50–59 years	17.2	18.9
60+ years	32.8	33.5
Education		
Primary school	33.9	34.3
Secondary or vocational education	31.7	30.8
Higher education	34.4	34.9

<sup>a</sup>According to the German Federal Statistical Office, 2021.



is crucial for consumers (Segovia and Palma 2016) and in accordance with EU regulations (Food Information Regulation No 1169/2011), which mandate that food packaging must disclose the country of origin or place of provenance, the attribute of origin—including the following levels: produced regionally, produced in Germany, and no information—was included into the experiment. Despite the legal requirement to provide information in the origin, we decided to include the “no information” attribute level for two key reasons: (1) It serves as a statistical baseline for comparing the impact of different attribute levels. (2) In practice, origin information is often placed on the back of packaging, making the absence of origin information on the front a familiar scenario for consumers. Additionally, the production method (i.e., organic and no information) was included. “No information” (i.e., participants did not receive any information) was the base level of all attributes, except for price. The price attribute ranged from €0.99/125 g to €2.99/125 g. The levels were selected according to average prices of raspberries in German supermarkets in April and May 2023.

The D-efficient design was generated using Stata 17 with the dcreate command written by Arne Risa Hole, University of Sheffield (Hole 2017). Based on the D-efficiency criterion, the

choice design with 11 choice sets, each consisting of three varying alternatives and a no-buy option, was selected. The no-buy option was included to reduce bias (Dhar and Simonson 2003) and to depict the most realistic market conditions (Risius and Hamm 2017). During the experiment, each participant was asked to choose from the set of three varying alternatives and the no-buy option, as if they were purchasing the product in a supermarket. The alternatives in each choice scenario, as well as the choice sets, were randomly presented, while the no-buy option was always presented last. Figure 1 depicts an example of a choice set presented to participants (please see Appendix B for the English translation).

Subsequent data analysis was performed with Stata 17. First, a random parameter logit (RPL) model was applied to assess the overall preference structure. RPL modeling aligns with random utility theory and builds on the same choice-probability model as the conditional logit. However, RPL accounts for preference heterogeneity by allowing preference weights to vary randomly across the sample. Unlike other methods, such as hierarchical Bayes estimation, which estimate individual-specific preferences, RPL models these preferences as deviations from the population mean rather than estimating them for each individual (Hauber et al. 2016). Given that RPL has been previously

TABLE 2 | Attributes and levels used in the discrete choice experiment.

Attribute	Attribute level
Production of green electricity	No information, with production of green electricity, without production of green electricity
Plastic usage	No information, with reduced plastic usage, with usual plastic usage for hail protection nets
Pesticide usage	No information, with reduced pesticide usage, with usual pesticide usage
Water usage	No information, with reduced water usage, with usual water usage
Production method	No information, organic farming
Origin	No information, produced regionally, produced in Germany, imported from Spain
Price	€0.99/125 g, €1.99/125 g, €2.99/125 g

Note: “No information” served as the base level for all attributes except for price.



FIGURE 1 | Example of a choice set presented to participants.

applied in the analysis of discrete choice experiments investigating consumer preferences for sustainable food (Risius and Hamm 2017; Sonntag et al. 2023) and the focus of this study was not on individual-level preference estimates, RPL was considered a suitable approach.

Effect coding was used for all attributes except for price, which was coded as a categorical variable, to avoid confounding with the no-buy option (Bech and Gyrd-Hansen 2005). As such, the attributes were coded with a value of 1 when applicable, a value of -1 for the base level (no information) and zero otherwise. Price was modeled as a random parameter. Subsequently, willingness-to-pay measures were calculated to allow for relative comparisons of attribute levels among attributes. The calculation of confidence intervals of WTP values followed Krinsky and Robb (1986). Second, a latent class conditional logit model was applied to account for individuals' preference heterogeneity (McFadden 1986; Yoo 2020) and the identification of distinct segments that differ according to their preferences. Again, effect coding was used for all attributes except for price. Due to the nonlinear decrease in the price-utility function in most segments, the price attribute was treated as categorical (Risius, Hamm, and Janssen 2019) and effect coded, too. To allow for relative comparisons among attributes, relative attribute importance was calculated. This was done by dividing the range of utility values for a specific attribute by the total sum of the ranges of utility values across all attributes (Malhotra 2009).

## 4 | Results

The results of the RPL model show the overall preference structure (see Table 3). All included attribute levels, except for organic, had a significant effect on consumers' purchasing decisions. Compared with "no information," "with production of green electricity" had a positive effect on consumers' choice, while a product labeled "without production of green electricity" negatively impacted consumers' choices. The information "reduced usage of plastic/pesticide/water" positively affected consumers' choices, while the "usual usage of plastic/pesticide/water" decreased consumers' marginal utility compared with "no information." Two attribute levels associated with the product's origin, namely "produced in Germany" and "regionally produced," had a positive influence on consumers' purchasing decisions, while marginal utility decreased for a product labeled "imported from Spain." Price had a negative coefficient, indicating that consumers' marginal utility decreased when the product price increased. WTP values allow for comparison among attributes and show that consumers valued the product level "with production of green electricity" the most. Specifically, for €0.27/125 g, consumers showed the highest WTP for raspberries labeled "with production of green electricity," followed by €0.26/125 g for "regionally produced," and €0.25/125 g for "produced in Germany." Further, WTP measures showed that consumers were willing to pay a price premium of €0.19/125 g for raspberries labeled "with reduced water usage," €0.19/125 g for "with reduced plastic usage," and €0.15/125 g for "with reduced pesticide usage." As the coefficient of the remaining attribute levels was negative, consequently, WTP was also negative, indicating that

consumers were not willing to pay a price premium for the described change in production.

Subsequently, latent class conditional modeling was applied. Based on the model fit criteria (see Table 4), four distinct segments within the sample were identified. Relative importance of the product attributes is depicted in Table 5. Results of the latent class conditional model are shown in Table 6.

Segment 1 is the largest group and accounts for 32.4% of the sample. For segment 1, price was most important attribute (29.97%), followed by pesticide usage (19.55%). With 9.85%, the production of green electricity was still important in the purchasing decision, but to a lesser extent. Latent class conditional logit analysis revealed that all attribute levels included in the experiment, except for the lower price level (€1.99/125 g), had a highly significant impact on consumers' buying decision. Product levels "with production of green electricity," "with reduced plastic usage," "with reduced pesticide usage," and "with reduced water usage" had a significant positive impact on consumers' purchasing decision compared with each attribute's base level "no information." Similarly, "organic," "produced regionally," and "produced in Germany" had a positive significant effect on consumers' purchase decision. All other coefficients had a significant negative effect on consumers' choices, indicating that raspberries labeled with those attribute levels led to decreased marginal utility. Accordingly, segment 1 was named "Price-conscious pesticide skeptics, less interested electricity production."

Segment 2 accounts for 22.4% of the sample. Relative product importance showed that for segment 2, with 24.39%, production of green electricity was the most important product attribute, followed by origin (21.78%). Price only accounted for a relative importance of 10.09% in the purchasing decision. Thus, segment 2 is the least price conscious compared with the other segments. The attribute levels "with production of green electricity," "with reduces water usage," "organic," "regionally produced," "produced in Germany," and "€1.99/125 g" had a significant positive coefficient, indicating that consumers obtained utility from those characteristics. "Reduced pesticide usage," "reduced plastic usage," and "usual plastic usage" had no significant impact on participants' choices. The same applied to the attribute level "€2.99/125 g," which also had no significant effect on consumers' choices, indicating that consumers associated with this segment were less price-conscious. "Without production of green electricity," "usual pesticide usage," "usual water usage," and "imported from Spain" had a negative significant coefficient, indicating that marginal utility decreased for raspberries labeled with those attributes. Accordingly, segment 2 was named "Less price-sensitive proponents of green electricity production."

Segment 3 is the smallest and accounts for 19.1% of the sample. Regarding the relative importance of attributes, individuals associated with segment 3 highly valued origin (38.05%), followed by price (14.01%) and production of green electricity (12.45%). The attribute levels "with production of green electricity," "reduced plastic usage," "usual water usage," "organic," "produced regionally," "produced in Germany," and "€1.99/125 g" had a significant positive coefficient, indicating that labeling raspberries with those attributes increased the utility for consumers and thus their likelihood to buy the product. The attribute level

TABLE 3 | Results of the random parameter logit model.

Attribute	Level	Coefficient	Standard error	WTP (€/125 g)	95% confidence interval <sup>b</sup>
Production of green electricity <sup>a</sup>	With production of green electricity	0.376***	0.040	0.27	0.207; 0.325
	Without production of green electricity	−0.271***	0.047	−0.19	−0.257; −0.128
Plastic usage <sup>a</sup>	With reduced plastic usage	0.259***	0.044	0.19	0.123; 0.249
	Usual plastic usage for hail protection nets	−0.114**	0.041	−0.08	−0.137; −0.025
Pesticide usage <sup>a</sup>	With reduced pesticide usage	0.213***	0.059	0.15	0.073; 0.239
	Usual pesticide usage	−0.328***	0.048	−0.23	−0.310; −0.163
Water usage <sup>a</sup>	With reduced water usage	0.272***	0.033	0.19	0.147; 0.245
	Usual water usage	−0.164***	0.038	−0.12	−0.170; −0.060
Production method <sup>a</sup>	Organic production	0.034 n.s.	0.036		n.s.
	Regionally produced	0.359***	0.055	0.26	0.174; 0.340
Origin <sup>a</sup>	Produced in Germany	0.354***	0.042	0.25	0.193; 0.310
	Imported from Spain	−0.735***	0.049	−0.52	−0.600; −0.453
Price		−1.402***	0.062		

Note: Log-likelihood: −4616.8901, Wald  $\chi^2 = 1095.39$ ,  $\text{prob} > \chi^2 = 0.0000$ .

<sup>a</sup>Reference category: “no information.”

<sup>b</sup>95% confidence interval following Krinsky and Robb (1986).

\*\*\* $p \leq 0.001$ , \*\* $p \leq 0.01$ , and \* $p \leq 0.05$ .



**TABLE 4** | Model fit criteria of the latent class analysis (LCA).

	Log-likelihood <sub>model</sub>	df	AIC	BIC	Sample size ≤ 10%
Segment 2	−4684.81	29	9427.624	9656.405	0
Segment 3	−4574.55	44	9237.104	9584.22	0
<b>Segment 4</b>	<b>−4481.38</b>	<b>59</b>	<b>9080.761</b>	<b>9546.211</b>	<b>0</b>
Segment 5	−4429.38	74	9006.756	9590.54	1
Segment 6	−4397.309	89	8972.618	9674.737	1
Segment 7	−4358.57	104	8925.139	9745.594	2

Note: The best-fitting model is presented in bold. Pseudo  $R^2$ : 0.13.

Abbreviations: AIC, Akaike information criteria; BIC, Bayesian information criteria.

**TABLE 5** | Attribute importance of the attributes included in the choice experiment and the respective segments.

Attributes	Segment 1	Segment 2	Segment 3	Segment 4	Average attribute importance
Production of green electricity	9.85%	24.39%	12.45%	12.09%	
Plastic usage	12.41%	9.18%	8.03%	1.30%	
Pesticide usage	19.55%	14.85%	11.36%	5.73%	
Water usage	9.26%	12.60%	11.74%	12.03%	
Production method	6.84%	7.11%	4.36%	3.42%	
Origin	14.13%	21.78%	38.05%	21.12%	
Price	27.97%	10.09%	14.01%	44.31%	

“usual pesticide usage” had no significant effect on consumers’ purchasing decisions. The remaining attribute levels had a negative coefficient, indicating decreasing marginal utility of products labeled with those characteristics. Based on this, individuals associated with this segment were labeled “import opponents, open to green electricity production.”

The remaining segment 4 accounts for 25.3% of the sample. For consumers of segment 4, price was the most important attribute (44.31%), followed by origin (21.12%). “Without production of green electricity,” “usual water usage,” and “produced in Germany” had a positive significant coefficient. “€2.99/125 g” and “imported from Spain” decreased consumers’ likelihood of purchasing the product. The remaining levels had no significant effect on consumers’ choices. Accordingly, individuals associated with this segment were named “Price-conscious consumers, not interested in green electricity.”

## 5 | Discussion

This study investigated consumers’ preferences for food produced in agrivoltaic systems, taking the example of raspberries. Overall, consumers’ WTP a price premium was highest for raspberries labeled with additional information regarding the simultaneous production of green electricity in the production process. This provides evidence for consumers valuing front-of-packing information of one of the major sustainability benefits of agrivoltaic systems—the production of green electricity. The results point in the same direction as previous literature

highlighting general public acceptance of solar energy production (Vuichard, Stauch, and Wüstenhagen 2021). Our results, thus, suggest that the marketing of food produced in agrivoltaic systems could benefit from information regarding the simultaneous production of green electricity and food. In contrast, explicitly highlighting that the production process did not include the production of green electricity yielded negative WTP values indicating a decreased likelihood for the purchase of food labeled with this respective attribute.

Origin and the associated product characteristics “produced regionally” and “produced in Germany” were also highly valued by consumers. Geographic origin has already been shown to be a highly valued product characteristic for fruits and vegetables purchases (Segovia and Palma 2016). Additionally, due to EU requirements, information regarding the country of origin is legally required. Thus, consumers are presumably used to be confronted with this product attribute when shopping for fruits and vegetables. In contrast to domestic and regional production that has already been shown to be appealing to consumers (Feldmann and Hamm 2015), imported raspberries from Spain yielded a highly negative WTP value. This result might be based on consumers’ perception of domestic production being a cue for high product quality (Witzling and Shaw 2019; Thøgersen 2023). Regarding the well-known strong consumer preference for the origin of food products, and the presumably high familiarity with information on the origin, it is remarkable that information on the production of green electricity yielded an even higher WTP value. These results might be based on the recently increasing socio-political interest in renewable energy

TABLE 6 | Coefficients ( $\beta$  values) of the levels of the latent class analysis.

Attributes	Levels	Segment 1	Segment 2	Segment 3	Segment 4
		Price-conscious pesticide skeptics, less interested in green electricity production	Less price-sensitive proponents of green electricity production	Import opponents, open to green electricity production	Price-conscious consumers, not interested in green electricity
		32.4%	22.4%	19.9%	25.3%
Production of green electricity	With production of green electricity	0.429***	0.410***	3.745***	0.446 n.s.
	Without production of green electricity	-0.290**	-0.356***	-2.099***	0.910*
Plastic usage	With reduced plastic usage	0.504***	0.136 n.s.	2.293***	-0.081 n.s.
	Usual plastic usage for hail protection nets	-0.402***	-0.153 n.s.	-3.032***	-0.081 n.s.
Pesticide usage	With reduced pesticide usage	0.674***	0.179 n.s.	-2.615***	0.603 n.s.
	Usual pesticide usage	-0.752***	-0.288**	-0.103 n.s.	-0.470 n.s.
Water usage	With reduced water usage	0.429***	0.261***	-1.218***	0.060 n.s.
	Usual water usage	-0.246***	-0.135*	3.366***	1.097*
Production method	Organic production	0.249**	0.112*	1.024***	0.320 n.s.
	Regionally produced	0.286*	0.305***	5.863***	1.916***
Origin	Produced in Germany	0.387***	0.185*	4.421***	0.916**
	Imported from Spain	-0.643***	-0.378***	-12.004***	-2.042***
Price	€1.99/125 g	0.113 n.s.	0.169*	0.995***	0.323 n.s.
	€2.99/125 g	-1.077***	-0.021 n.s.	-3.787***	-4.312***

Note: Reference category: "no information."

Abbreviation: n.s., nonsignificant.

\*\*\* $p \leq 0.001$ , \*\* $p \leq 0.01$ , and \* $p \leq 0.05$ .

sources (European Union 2023). Furthermore, interpretation of the results must take into account that participants in this study received extensive information on agrivoltaic systems prior to the experiment, which may have caused the consumers' strong preference for the production of green electricity. In other words, this highlights the importance of providing consumers with thorough information when marketing unfamiliar product characteristics.

Similar to recent studies showing consumers' interest in sustainable food production practices (Sonntag et al. 2023; Sadraei et al. 2023), the attribute levels describing other sustainable aspects of the food production in agrivoltaic system led to positive WTP values. Information on the benefits of agrivoltaic-food production regarding reduced plastic and water usage were valued similarly. As shown in previous research, the majority of consumers seems to be aware of the negative environmental impact of plastic packaging (Macht, Klink-Lehmann, and Venghaus 2023). This awareness also extends to reduced plastic usage in the production process. However, simply labeling agrivoltaic food products with the claim "less plastic usage" without providing additional information regarding the specific production processes in agrivoltaic systems might confuse consumers. Regarding the marketing of agrivoltaic food products, combining environmental friendly packaging, and not plastic packaging like in this study, with information regarding the reduced plastic usage in the production process might even increase consumers' acceptance.

Consumer preference for water efficiency in food production has so far received limited scientific attention. In line with the few studies that specifically investigated consumers' preferences for water usage in fruit production (Tait, Saunders, and Guenther 2015), our results showed a strong consumer interest in production processes with reduced water usage. Although consumers have access to various sustainability (e.g., climate or ecological labeling) and health-related information about food production, details on water usage are lacking so far. The results of this study provide evidence that consumers have extended their interest in sustainable production processes to include concerns about water usage in food production.

Studies by Koch et al. (2017) and Simoglou and Roditakis (2022) already identified that consumers perceive pesticide residues in food products as major risks to human health. It is, thus, less surprising that food labeled "with less pesticide usage" was valued in the present study whereas "with usual pesticide usage" was not. These results might be based on the fact that consumers are aware of the higher risk of pesticide residues in conventional berries (Verbraucherzentrale Niedersachsen 2023) and thus value less-pesticide usage. Our results suggest that additional information regarding the reduced usage of pesticides could serve as a promising front-of-food packaging information to increase consumers' acceptance of food produced in agrivoltaic systems.

In contrast to a wide range of literature identifying that "organic" is a favored product attribute for consumers when buying food (Aitken et al. 2020), our results showed that, overall, "organic" does not affect consumers' purchasing decisions. These results might be due to the fact that the other product characteristics included in our experiment already accounted for product

characteristics that consumers value when buying organic food (Sadiq, Adil, and Paul 2023). For instance, when buying organic, consumers automatically associate the products with less pesticide usage and less environmental impact (e.g., water usage and plastic usage) (Kushwah et al. 2019).

As already suggested in previous studies on sustainable innovations and technologies (Siegrist and Hartmann 2020; Jaeger, Chheang, and Ares 2023), distinct segments exist that differ according to how different product attributes are being valued. The four segments identified in this study showed indeed the existence of heterogenous preferences for the product attributes of raspberries produced in agrivoltaic systems.

Segment 1 appreciates the product characteristics of agrivoltaic systems (e.g., reduced pesticide usage, reduced plastic usage, and reduced water usage), indicating that segment 1 values sustainable product attributes. A recent study by Piracci et al. (2023) also identified a segment of 32.3% of individuals strongly interested in various sustainable dimensions when it comes to food shopping. However, in the present study, for segment 1, price was the most important product characteristic. Previous literature has already shown price to be a major barrier when it comes to a sustainable transition of consumption practices (Lopes, Pinho, and Gomes 2023; Hageman et al. 2024). Similarly, various consumer segmentation studies found consumer segments that are highly price conscious when choosing food (Apostolidis and McLeay 2016; Niedermeier, Emberger-Klein, and Menrad 2021). Communicating the sustainable benefits more intensively, and thus highlighting the additional value of food products from agrivoltaic systems, might help to overcome the higher price barrier of this segment.

Segment 2 offers the best chance to convince consumers to buy food produced in agrivoltaic systems. As such, individuals associated with segment 2 are characterized by a low price sensitivity and a high interest in the production of green electricity while simultaneously disliking raspberry production that produced no green electricity. For individuals associated with segment 2, higher prices for more sustainably produced foods are less of a barrier than for most other consumers (Apostolidis and McLeay 2016). Providing information on the production of green electricity as well as its origin, for instance by means of front-of-package labeling or additional information provided through flyers, will be valued by individuals associated with segment 2.

Individuals associated with segment 3 also value product characteristics associated with agrivoltaic systems, such as "with green electricity production" and "reduced plastic/water/pesticide usage." However, relatively, the "origin" of raspberries is the most important product attribute. Consumers prefer raspberries from "regional production" and "production in Germany" over products "imported from Spain." Previous studies already identified that some consumers highly value domestic food production (Segovia and Palma 2016). To encourage individuals in segment 3 to buy food produced in agrivoltaic systems, highlighting domestic origin might be helpful.

Segment 4 is highly price conscious and less interested in the benefits that food production in agrivoltaic systems could offer. This result is comparable with the study by Piracci et al. (2023),

which also identified a segment that is mainly focused on economic benefits rather than on sustainability. Surprisingly, even food grown “without production of green electricity” as well as “usual water usage” had a positive influence on the purchasing decision of consumers in segment 4. One explanation for this might be that consumers associate the additional production of green electricity as well as “usual water usage” with higher product prices because they know the costly usage of those resources from their own household. Segment 4 will be difficult to reach with communication and marketing approaches. Similarly, studies on sustainable food products (Wendt and Weinrich 2023) as well as on novel farming practices (Giacalone and Jaeger 2023) also identified consumer groups that were classified as less open to the target products. Reaching those consumers will be challenging, and marketing and communication approaches should rather address consumers already interested in sustainable product attributes and the simultaneous production of green electricity.

## 6 | Conclusion

Agrivoltaic systems offer great potential to solve the conflict regarding limited land resources. The results of this study highlight the potential of food products from agrivoltaic systems by showing that three quarters of German consumers are generally open to the simultaneous production of green electricity and foods. Based on our results, it can be assumed that agrivoltaic systems have the potential to be accepted by consumers on a large scale. Especially consumers already strongly interested in the production of green electricity should be motivated to further support sustainable farming systems, such as agrivoltaic systems. Especially, if consumers are provided with clear and transparent information of the benefits of the symbiotic production of green electricity and food, the acceptance might further increase (Rahman and Nguyen-Viet 2023). This is crucial for the successful implementation of agrivoltaic systems on a larger scale (Cousse 2021).

## 7 | Limitations and Future Research

As with any research, this study has limitations that can guide future studies. The experimental design did not include any constraints (e.g., excluding combinations that are not available at the market). Although this approach offered statistical benefits in terms of efficiency, it risked presenting participants with combinations of the attribute levels organic production and with reduced/usual pesticide usage. Well-informed consumers might have experienced confusion, potentially introducing bias into our results. However, because participants always had the option to choose “no-buy,” any related biases are likely minimal. Prior to the experiment, participants were informed about the production process of agrivoltaic systems. Given consumers' limited understanding of production methods and the low adoption of agrivoltaic systems, this approach was reasonable to ensure that participants understood the product characteristics related to the production process. Consumers' interest in the product characteristics of food produced in agrivoltaic systems, as revealed in this study, however, needs to be interpreted in this context. Because this study only investigated raspberries, the results can only be transferred to similar products (e.g., fruits/vegetables) and not

to other product categories (e.g., meat and dairy). In addition, although raspberry consumption is comparably high in Germany, raspberries may not be consumed on a daily basis, but rather purchased for special occasions or based on seasonal availability. Thus, using a more frequently consumed product might help to generalize consumers' acceptance to fruits and vegetables from agrivoltaic systems. Furthermore, this study focused on Germany. To eliminate cultural influences, future studies should investigate consumer preferences in other countries as well. Lastly, the results of this study are based on a hypothetical choice experiment. Although we ensured high data quality by including a cheap talk script, there is a need to investigate consumers' willingness to buy in real-life settings with real economic consequences.

## Acknowledgments

Open Access funding enabled and organized by Projekt DEAL.

## References

- Aitken, R., L. Watkins, J. Williams, and A. Kean. 2020. “The Positive Role of Labelling on Consumers' Perceived Behavioural Control and Intention to Purchase Organic Food.” *Journal of Cleaner Production* 255: 120334. <https://doi.org/10.1016/j.jclepro.2020.120334>.
- Ammann, J., G. Mack, N. El Benni, et al. 2024. “Consumers Across Five European Countries Prioritise Animal Welfare Above Environmental Sustainability When Buying Meat and Dairy Products.” *Food Quality and Preference* 117: 105179. <https://doi.org/10.1016/j.foodqual.2024.105179>.
- Apostolidis, C., and F. McLeay. 2016. “Should We Stop Meating Like This? Reducing Meat Consumption Through Substitution.” *Food Policy* 65: 74–89. <https://doi.org/10.1016/j.foodpol.2016.11.002>.
- Bangsa, A. B., and B. B. Schlegelmilch. 2020. “Linking Sustainable Product Attributes and Consumer Decision-Making: Insights From a Systematic Review.” *Journal of Cleaner Production* 245: 118902. <https://doi.org/10.1016/j.jclepro.2019.118902>.
- Bannor, R. K., and S. Abele. 2021. “Consumer Characteristics and Incentives to Buy Labelled Regional Agricultural Products.” *World Journal of Entrepreneurship, Management and Sustainable Development* 17, no. 4: 872–888. <https://doi.org/10.1108/WJEMSD-12-2020-0173>.
- Bech, M., and D. Gyrd-Hansen. 2005. “Effects Coding in Discrete Choice Experiments.” *Health Economics* 14, no. 10: 1079–1083. <https://doi.org/10.1002/hec.984>.
- Bundesamt für Verbraucherschutz und Lebensmittelsicherheit. 2023. “Nationale Berichterstattung Pflanzenschutzmittelrückstände in Lebensmitteln.” Retrieved from [https://www.bvl.bund.de/SharedDocs/Downloads/01\\_Lebensmittel/nbpsm/00\\_Berichte/NBPSMR\\_2021.pdf?\\_\\_blob=publicationFile&v=7](https://www.bvl.bund.de/SharedDocs/Downloads/01_Lebensmittel/nbpsm/00_Berichte/NBPSMR_2021.pdf?__blob=publicationFile&v=7).
- Bundesanstalt für Landwirtschaft und Ernährung. 2021. “Pro-Kopf-Verbrauch von Strauchbeeren: 5,1 Kilogramm.” Retrieved from [https://www.ble.de/SharedDocs/Downloads/DE/Pressemitteilungen/2021/210616\\_Strauchbeeren.pdf?sessionid=D5C5DB89975B0ADFC7CAFE66F7A63DCF.internet951?\\_\\_blob=publicationFile&v=3](https://www.ble.de/SharedDocs/Downloads/DE/Pressemitteilungen/2021/210616_Strauchbeeren.pdf?sessionid=D5C5DB89975B0ADFC7CAFE66F7A63DCF.internet951?__blob=publicationFile&v=3).
- Chinedu, O., E. Sanou, J. Tur-Cardona, F. Bartolini, G. Gheysen, and S. Speelman. 2018. “Farmers' Valuation of Transgenic Biofortified Sorghum for Nutritional Improvement in Burkina Faso: A Latent Class Approach.” *Food Policy* 79: 132–140. <https://doi.org/10.1016/j.foodpol.2018.06.006>.
- Connor, M., and M. Siegrist. 2010. “Factors Influencing people's Acceptance of Gene Technology: The Role of Knowledge, Health Expectations, Naturalness, and Social Trust.” *Science Communication* 32, no. 4: 514–538. <https://doi.org/10.1177/1075547009358919>.



- Cousse, J. 2021. "Still in Love With Solar Energy? Installation Size, Affect, and the Social Acceptance of Renewable Energy Technologies." *Renewable and Sustainable Energy Reviews* 145: 111107. <https://doi.org/10.1016/j.rser.2021.111107>.
- Darby, M. R., and E. Karni. 1973. "Free Competition and the Optimal Amount of Fraud." *Journal of Law and Economics* 16, no. 1: 67–88. <https://doi.org/10.1086/466756>.
- Destatis (Statistisches Bundesamt). 2023. "Strauchbeerenernte 2022 um 6% Gesunken." Retrieved from [https://www.destatis.de/DE/Presse/Pressemitteilungen/2023/02/PD23\\_053\\_412.html](https://www.destatis.de/DE/Presse/Pressemitteilungen/2023/02/PD23_053_412.html).
- Dhar, R., and I. Simonson. 2003. "The Effect of Forced Choice on Choice." *Journal of Marketing Research* 40, no. 2: 146–160. <https://doi.org/10.1509/jmkr.40.2.146.19229>.
- Di Vita, G., R. Vecchio, M. Borrello, et al. 2021. "Oh my Darling Clementine: Heterogeneous Preferences for Sustainable Citrus Fruits." *Renewable Agriculture and Food Systems* 36, no. 6: 557–568. <https://doi.org/10.1017/S174217052100017X>.
- Elamri, Y., B. Cheviron, A. Mange, C. Dejean, F. Liron, and G. Belaud. 2018. "Rain Concentration and Sheltering Effect of Solar Panels on Cultivated Plots." *Hydrology and Earth System Sciences* 22, no. 2: 1285–1298. <https://doi.org/10.5194/hess-22-1285-2018>.
- European Commission. 2019. "The European Green Deal." Retrieved from <https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1576150542719&uri=COM%3A2019%3A640%3AFIN>.
- European Union. 2023. "Special Eurobarometer 538: Climate Change." Retrieved from <https://doi.org/10.2834/653431>.
- Feldmann, C., and U. Hamm. 2015. "Consumers' Perceptions and Preferences for Local Food: A Review." *Food Quality and Preference* 40: 152–164. <https://doi.org/10.1016/j.foodqual.2014.09.014>.
- Fuller, K., and C. Grebitus. 2023. "Consumers' Preferences and Willingness to Pay for Coffee Sustainability Labels." *Agribusiness* 39, no. 4: 1007–1025. <https://doi.org/10.1002/agr.21810>.
- Gandorfer, M., A. Hartwich, and V. Bitsch. 2016. "Hail Risk Management in Fruit Production: Anti-Hail Net Versus Hail Insurance in Germany." *Acta Horticulturae* 1132: 141–146. <https://doi.org/10.17660/ActaHortic.2016.1132.19>.
- Giacalone, D., and S. R. Jaeger. 2023. "Consumer Acceptance of Novel Sustainable Food Technologies: A Multi-Country Survey." *Journal of Cleaner Production* 408: 137119. <https://doi.org/10.1016/j.jclepro.2023.137119>.
- Hageman, E., V. Kumar, L. Duong, A. Kumari, and E. McAuliffe. 2024. "Do Fast Fashion Sustainable Business Strategies Influence Attitude, Awareness and Behaviours of Female Consumers?." *Business Strategy and the Environment* 33, no. 2: 1081–1098. <https://doi.org/10.1002/bse.3545>.
- Hauber, A. B., J. M. González, C. G. M. Groothuis-Oudshoorn, et al. 2016. "Statistical Methods for the Analysis of Discrete Choice Experiments: A Report of the Ispor Conjoint Analysis Good Research Practices Task Force." *Value in Health* 19, no. 4: 300–315. <https://doi.org/10.1016/j.jval.2016.04.004>.
- Hole, A. R. 2017. "DCREATE: Stata Module to Create Efficient Designs for Discrete Choice Experiments." Statistical Software Components S458059. Boston College Department of Economics.
- Hueppe, R., and K. Zander. 2024. "Perfect Apples or Sustainable Production?—Consumer Perspectives From Germany." *Journal of Consumer Behaviour* 23, no. 2: 698–710. <https://doi.org/10.1002/cb.2236>.
- ISE (Fraunhofer Institute for Solar Energy Systems). 2022. "Agrivoltaics: Opportunities for Agriculture and the Energy Transition." Retrieved from <https://www.ise.fraunhofer.de/content/dam/ise/en/documents/publications/studies/APV-Guideline.pdf>.
- Iweala, S., A. Spiller, R. M. Nayga, and D. Lemken. 2022. "Warm Glow and Consumers' Valuation of Ethically Certified Products." *Q Open* 2, no. 2: qoac020. <https://doi.org/10.1093/qopen/qoac020>.
- Jaeger, S. R., S. L. Chheang, and G. Ares. 2023. "How Positive and Negative Attitudes to Vertical Farming Influence Purchase Likelihood: Consumer Insights From the United States, Germany, Singapore and Australia." *Journal of Cleaner Production* 415: 137752. <https://doi.org/10.1016/j.jclepro.2023.137752>.
- Jürkenbeck, K., F. von Steimker, and A. Spiller. 2024. "Consumer's Perception of Food Pairing Products With Usual, Novel and Unusual Flavour Combinations: A Segmentation Approach." *Appetite* 196: 107270. <https://doi.org/10.1016/j.appet.2024.107270>.
- Koch, S., A. Epp, M. Lohmann, and G.-F. Böhl. 2017. "Pesticide Residues in Food: Attitudes, Beliefs, and Misconceptions Among Conventional and Organic Consumers." *Journal of Food Protection* 80, no. 12: 2083–2089. <https://doi.org/10.4315/0362-028X.JFP-17-104>.
- Koutsimanis, G., K. Getter, B. Behe, J. Harte, and E. Almenar. 2012. "Influences of Packaging Attributes on Consumer Purchase Decisions for Fresh Produce." *Appetite* 59, no. 2: 270–280. <https://doi.org/10.1016/j.appet.2012.05.012>.
- Krinsky, I., and A. L. Robb. 1986. "On Approximating the Statistical Properties of Elasticities." *Review of Economics and Statistics* 68, no. 4: 715–719. <https://doi.org/10.2307/1924536>.
- Kushwah, S., A. Dhir, M. Sagar, and B. Gupta. 2019. "Determinants of Organic Food Consumption: A Systematic Literature Review on Motives and Barriers." *Appetite* 143: 104402. <https://doi.org/10.1016/j.appet.2019.104402>.
- Lancaster, K. J. 1966. "A New Approach to Consumer Theory." *Journal of Political Economy* 74, no. 2: 132–157. <https://doi.org/10.1086/259131>.
- Langer, G., and S. Köhl. 2024. "Perception and Acceptance of Robots in Dairy Farming—A Cluster Analysis of German Citizens." *Agriculture and Human Values* 41, no. 1: 249–267. <https://doi.org/10.1007/s10460-023-10483-x>.
- Liu, W., C. Wang, and A. P. J. Mol. 2013. "Rural Public Acceptance of Renewable Energy Deployment: The Case of Shandong in China." *Applied Energy* 102: 1187–1196. <https://doi.org/10.1016/j.apenergy.2012.06.057>.
- Lohrer, R. n.d. "BayWa r.e. Baut größtes Fruitvoltaic—Projekt in Europa." Retrieved from <https://www.baywa-re.de/de/unternehmen/news/details/baywa-re-baut-groesstes-fruitvoltaic-projekt-in-europa>.
- Lopes, J. M., M. Pinho, and S. Gomes. 2023. "From Green Hype to Green Habits: Understanding the Factors That Influence Young Consumers' Green Purchasing Decisions." *Business Strategy and the Environment* 33: 2432–2444. <https://doi.org/10.1002/bse.3602>.
- Lusk, J. L. 2003. "Effects of Cheap Talk on Consumer Willingness-To-Pay for Golden Rice." *American Journal of Agricultural Economics* 85, no. 4: 840–856. <https://doi.org/10.1111/1467-8276.00492>.
- Macht, J., J. Klink-Lehmann, and S. Venghaus. 2023. "Eco-Friendly Alternatives to Food Packed in Plastics: German Consumers' Purchase Intentions for Different Bio-Based Packaging Strategies." *Food Quality and Preference* 109: 104884. <https://doi.org/10.1016/j.foodqual.2023.104884>.
- Malhotra, N. K. 2009. *Marketing Research: An Applied Orientation*. 6th ed. Harlow: Pearson Education Limited.
- Marrou, H., J. Wery, L. Dufour, and C. Dupraz. 2013. "Productivity and Radiation Use Efficiency of Lettuces Grown in the Partial Shade of Photovoltaic Panels." *European Journal of Agronomy* 44: 54–66. <https://doi.org/10.1016/j.eja.2012.08.003>.
- Mazzocchi, C., G. Ruggeri, and S. Corsi. 2019. "Consumers' Preferences for Biodiversity in Vineyards: A Choice Experiment on Wine." *Wine Economics and Policy* 8, no. 2: 155–164. <https://doi.org/10.1016/j.wep.2019.09.002>.



- McFadden, D. 1986. "The Choice Theory Approach to Market Research." *Marketing Science* 5, no. 4: 275–297. <https://doi.org/10.1287/mksc.5.4.275>.
- Niedermeier, A., A. Emberger-Klein, and K. Menrad. 2021. "Which Factors Distinguish the Different Consumer Segments of Green Fast-Moving Consumer Goods in Germany?" *Business Strategy and the Environment* 30, no. 4: 1823–1838. <https://doi.org/10.1002/bse.2718>.
- Oh, C.-O., Z. Herrnsstadt, and P. H. Howard. 2015. "Consumer Willingness to Pay for Bird Management Practices in Fruit Crops." *Agroecology and Sustainable Food Systems* 39, no. 7: 782–797. <https://doi.org/10.1080/21683565.2015.1017896>.
- Péneau, S., E. Hoehn, H.-R. Roth, F. Escher, and J. Nuessli. 2006. "Importance and Consumer Perception of Freshness of Apples." *Food Quality and Preference* 17, no. 1–2: 9–19. <https://doi.org/10.1016/j.foodqual.2005.05.002>.
- Peschel, A. O., C. Grebitus, B. Steiner, and M. Veeman. 2016. "How Does Consumer Knowledge Affect Environmentally Sustainable Choices? Evidence From a Cross-Country Latent Class Analysis of Food Labels." *Appetite* 106: 78–91. <https://doi.org/10.1016/j.appet.2016.02.162>.
- Piracci, G., L. Casini, C. Contini, C. M. Stancu, and L. Lähteenmäki. 2023. "Identifying Key Attributes in Sustainable Food Choices: An Analysis Using the Food Values Framework." *Journal of Cleaner Production* 416: 137924. <https://doi.org/10.1016/j.jclepro.2023.137924>.
- Raaijmakers, I., S. Sijtsma, C. Labrie, and H. Snoek. 2018. "Consumer Segmentation Based on Health-Related Motive Orientations and Fruit and Vegetable Consumption." *British Food Journal* 120, no. 8: 1749–1763. <https://doi.org/10.1108/BFJ-02-2018-0098>.
- Rahman, S. U., and B. Nguyen-Viet. 2023. "Towards Sustainable Development: Coupling Green Marketing Strategies and Consumer Perceptions in Addressing Greenwashing." *Business Strategy and the Environment* 32, no. 4: 2420–2433. <https://doi.org/10.1002/bse.3256>.
- Risius, A., and U. Hamm. 2017. "The Effect of Information on Beef Husbandry Systems on Consumers' Preferences and Willingness to Pay." *Meat Science* 124: 9–14. <https://doi.org/10.1016/j.meatsci.2016.10.008>.
- Risius, A., U. Hamm, and M. Janssen. 2019. "Target Groups for Fish From Aquaculture: Consumer Segmentation Based on Sustainability Attributes and Country of Origin." *Aquaculture* 499: 341–347. <https://doi.org/10.1016/j.aquaculture.2018.09.044>.
- Rogers, J. C., E. A. Simmons, I. Convery, and A. Weatherall. 2008. "Public Perceptions of Opportunities for Community-Based Renewable Energy Projects." *Energy Policy* 36, no. 11: 4217–4226. <https://doi.org/10.1016/j.enpol.2008.07.028>.
- Román, S., L. M. Sánchez-Siles, and M. Siegrist. 2017. "The Importance of Food Naturalness for Consumers: Results of a Systematic Review." *Trends in Food Science & Technology* 67: 44–57. <https://doi.org/10.1016/j.tifs.2017.06.010>.
- Sadiq, M., M. Adil, and J. Paul. 2023. "Organic Food Consumption and Contextual Factors: An Attitude–Behavior–Context Perspective." *Business Strategy and the Environment* 32, no. 6: 3383–3397. <https://doi.org/10.1002/bse.3306>.
- Sadraei, R., P. Biancone, F. Lanzalunga, V. Jafari-Sadeghi, and F. Chmet. 2023. "How to Increase Sustainable Production in the Food Sector? Mapping Industrial and Business Strategies and Providing Future Research Agenda." *Business Strategy and the Environment* 32, no. 4: 2209–2228. <https://doi.org/10.1002/bse.3244>.
- Schulze, M., A. Spiller, and K. Jürkenbeck. 2022. "Politicised Opinion Leaders in the Younger Generation: To Meat or Not to Meat?" *British Food Journal* 124, no. 11: 3907–3921. <https://doi.org/10.1108/BFJ-07-2021-0817>.
- Schulze, M., A. Spiller, and A. Risius. 2021. "Do Consumers Prefer Pasture-Raised Dual-Purpose Cattle When Considering Meat Products? A Hypothetical Discrete Choice Experiment for the Case of Minced Beef." *Meat Science* 177: 108494. <https://doi.org/10.1016/j.meatsci.2021.108494>.
- Scott, S. E., Y. Inbar, C. D. Wirz, D. Brossard, and P. Rozin. 2018. "An Overview of Attitudes Toward Genetically Engineered Food." *Annual Review of Nutrition* 38, no. 1: 459–479. <https://doi.org/10.1146/annurev-nutr-071715-051223>.
- Segovia, M. S., and M. A. Palma. 2016. "Buying Your Way Into a Healthier Lifestyle: A Latent Class Analysis of Healthy Food Purchases." *Applied Economics* 48, no. 21: 1965–1977. <https://doi.org/10.1080/00036846.2015.1111988>.
- Siegrist, M., and C. Hartmann. 2020. "Consumer Acceptance of Novel Food Technologies." *Nature Food* 1, no. 6: 343–350. <https://doi.org/10.1038/s43016-020-0094-x>.
- Simoglou, K. B., and E. Roditakis. 2022. "Consumers' Benefit—Risk Perception on Pesticides and Food Safety—A Survey in Greece." *Agriculture* 12, no. 2: 192. <https://doi.org/10.3390/agriculture12020192>.
- Sinha, P., B. Hoffman, J. Sakers, and L. Althouse. 2018. "Best Practices in Responsible Land Use for Improving Biodiversity at a Utility-Scale Solar Facility." *Case Studies in the Environment* 2, no. 1: 1–12. <https://doi.org/10.1525/cse.2018.001123>.
- Sonntag, W., D. Lemken, A. Spiller, and M. Schulze. 2023. "Welcome to the (Label) Jungle? Analyzing How Consumers Deal With Intra-Sustainability Label Trade-Offs on Food." *Food Quality and Preference* 104: 104746. <https://doi.org/10.1016/j.foodqual.2022.104746>.
- Tait, P. R., C. Saunders, and M. Guenther. 2015. "Valuing Preferences for Environmental Sustainability in Fruit Production by United Kingdom and Japanese Consumers." *Journal of Food Research* 4, no. 3: 46. <https://doi.org/10.5539/jfr.v4n3p46>.
- Tesvolt. 2023. "Free to Go Green: Ergebnisse der repräsentativen Umfrage zur Energiewende in Deutschland." Retrieved from [https://www.tesvolt.com/\\_media/06%20UNTERNEHMEN/01\\_Presse/2023/03\\_Forsa-Umfrage/TESVOLT\\_forsa\\_Ergebnispraesentation\\_Energiewende\\_Download.pdf](https://www.tesvolt.com/_media/06%20UNTERNEHMEN/01_Presse/2023/03_Forsa-Umfrage/TESVOLT_forsa_Ergebnispraesentation_Energiewende_Download.pdf).
- Thøgersen, J. 2023. "How Does Origin Labelling on Food Packaging Influence Consumer Product Evaluation and Choices? A Systematic Literature Review." *Food Policy* 119: 102503. <https://doi.org/10.1016/j.foodpol.2023.102503>.
- Toledo, C., and A. Scognamiglio. 2021. "Agrivoltaic Systems Design and Assessment: A Critical Review, and a Descriptive Model Towards a Sustainable Landscape Vision (Three-Dimensional Agrivoltaic Patterns)." *Sustainability* 13, no. 12: 6871. <https://doi.org/10.3390/su13126871>.
- Verbraucherzentrale Niedersachsen. 2023. "Welche Lebensmittel sind mit Pestiziden belastet?" Retrieved from <https://www.verbraucherzentrale-niedersachsen.de/themen/ernaehrung-lebensmittel/kennzeichnung-inhaltsstoffe/welche-lebensmittel-sind-pestiziden-belastet>.
- Vuichard, P., A. Stauch, and R. Wüstenhagen. 2021. "Keep It Local and Low-Key: Social Acceptance of Alpine Solar Power Projects." *Renewable and Sustainable Energy Reviews* 138: 110516. <https://doi.org/10.1016/j.rser.2020.110516>.
- Wendt, M.-C., and R. Weinrich. 2023. "Consumer Segmentation for Pesticide-Free Food Products in Germany." *Sustainable Production and Consumption* 42: 309–321. <https://doi.org/10.1016/j.spc.2023.10.005>.
- Weselek, A., A. Ehmann, S. Zikeli, I. Lewandowski, S. Schindele, and P. Högy. 2019. "Agrophotovoltaic Systems: Applications, Challenges, and Opportunities. A Review." *Agronomy for Sustainable Development* 39, no. 4: 35. <https://doi.org/10.1007/s13593-019-0581-3>.
- Witzling, L., and B. R. Shaw. 2019. "Lifestyle Segmentation and Political Ideology: Toward Understanding Beliefs and Behavior About Local Food." *Appetite* 132: 106–113. <https://doi.org/10.1016/j.appet.2018.10.003>.
- Yoo, H. I. 2020. "Lclogit2: An Enhanced Command to Fit Latent Class Conditional Logit Models." *Stata Journal: Promoting Communications on Statistics and Stata* 20, no. 2: 405–425. <https://doi.org/10.1177/1536867X20931003>.

## Appendix A

### Informational Treatment (*originally in German, translated to English*)

The following is about an innovative cultivation method for food, agri-voltaics (AV). AV systems generate green electricity and food at the same time on the same area of land. This is what agrivoltaic systems look like:



How do AV systems work? Here is an example.

An AV system produces green electricity and food at the same time. Apples or raspberries, for example, can be grown with this system. The solar panel structure protects the plants underneath from extreme weather conditions such as hail or heat. This protective function means that less water, fewer pesticides, and less plastic are required for cultivation in the orchard. Water consumption is reduced as the plants are shaded by the panels; thus, less water evaporates. The use of pesticides is reduced because the system protects the plants from moisture through rain and dew, resulting in fewer fungal diseases. Plastic consumption is reduced because the system protects the plants from hail, for which plastic hail protection nets would otherwise be used.

For comparison, conventional cultivation looks like this:



## Appendix B

Example of a choice set presented to participants (*originally in German, translated to English*)

