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Claim preferences of consumers for vegetables from pesticide-free agriculture: a survey experiment

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Summary

Sustainable consumption decisions can be promoted by claims on food. It is essential that the claims are consumer-oriented. In this light, the consumer evaluation of different labelling variants for pesticide-free vegetables was recorded for three claims on the pesticide renunciation and four claims on sustainability-related consequences of the pesticide renunciation. An online survey was conducted with 953 German consumers. Each participant was randomly assigned to one of seven subsamples. Each subsample evaluated one of seven claims. The evaluations show that all claims were rated as "moderately" to "quite understandable" and appropriate to the cultivation form and would "perhaps" to "quite probably" be helpful in the purchase decision. Further, the claims on pesticide renunciation were perceived as more understandable, more appropriate for the cultivation form and more helpful for the purchase decision compared to the claims on sustainability-related consequences. The findings are useful for actors in the agricultural and food sector.

Keywords

pesticide-free vegetables, sustainable consumption, food choice, food labelling

Introduction

Sustainability motives are increasingly important when buying food (Verain et al., 2021; Sautron et al., 2015). The availability of adequate information on sustainability-related product characteristics is a prerequisite for more sustainable consumption choices (Leire & Thidell, 2005). In this context, information economy deals with the functioning of market processes in the case of asymmetric information distribution between the market sides (Spiller, 2019). The supplier of a good has precise knowledge about its quality. For consumers, the attributes of a product can be verified to varying degrees in the end product (Koch, 2005; Meyer-Höfer & Spiller, 2016). Existing information asymmetries can refer to the completeness of the information and the reliability of the information (Tietzel & Weber, 1991). The degree of information asymmetry between suppliers and consumers varies depending on the product attributes under consideration. In general, a distinction can be made between four types of attributes for food, which can be verified by different degrees on the end product: search, experience, credence, and "Potemkin" attributes (Hirshleifer, 1973; Gawel, 1997; Tietzel & Weber, 1991). Search attributes (e.g., fruit color) show the lowest degree of information asymmetry. They can be inspected by the consumer before purchasing a good. Experience attributes (e.g., taste) can only be inspected by the consumer after purchase or during consumption. Credence attributes (e.g., local origin, organic production; Dahlhausen et al., 2018) cannot be verified even after purchase or during use. "Potemkin" attributes have the highest degree of information asymmetry. These are attributes that a product only appears to have. The actual nature of the attribute cannot easily be "revealed" by the consumer in the end product. The consumer has no information about the actual nature of the attribute. In addition, the actual nature of the attribute cannot be identified during consumption. The consumer is mistaken about the attribute in question. For example, a wine may not have its color by nature, but through the addition of glycol (Tietzel & Weber, 1991).

Pesticide-free cultivation or the presence/absence of pesticide residues in food are credence attributes. Claims or labels can transform these otherwise "hidden" properties into search attributes (Freese, 2010; Grolleau & Caswell, 2006). These product stimuli can be perceived directly and influence the purchase decision process.

In this light, the present study focuses on the consumer assessment of different claim variants for vegetables grown in an agricultural land use management form that is characterized by the use of mineral fertilizers and the absence of pesticides. Instead of pesticides, alternative measures are taken to control weeds (e.g., hoeing of weeds) and to protect the plants from pests (e.g., use of natural enemies) and diseases (e.g., selection of resistant varieties) (Zimmermann et al., 2021). This cultivation method is a "hybrid" agricultural land

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use management form that is located between organic and conventional agriculture (Spiller & Iweala, 2022). Conventional and organic agriculture are the two most established land use management forms. In conventional agriculture, synthetic chemical pesticides and mineral fertilizers are used. If pesticides are used responsibly, positive sustainability-related effects can result. Yields can be increased. This contributes to securing food for the growing world population. At the same time, arable land can be conserved. In addition, susceptibility to pests and diseases can be reduced (Frische et al., 2018; Lykogianni et al., 2021). However, the intensive use of synthetic chemical pesticides is associated with negative sustainability-related consequences (Silva et al., 2019; Tudi et al., 2021). In organic agriculture, both synthetic chemical pesticides and mineral fertilizers are avoided. Compared to conventional agriculture, organic agriculture provides higher ecosystem services (Mondelaers et al., 2009; Tuck et al., 2014). However, yields in organic farming are lower than in conventional farming (Tuomisto et al., 2012; Seufert & Ramankutty, 2017). Pesticide-free agriculture as a "hybrid" land use management form makes it possible to secure crop yields and product quality. At the same time, negative sustainability-related consequences resulting from an intensive use of pesticides can be prevented (Zimmermann et al., 2021; Ali et al., 2021).

The aim of many European countries is to reduce the use of pesticides. So far, pesticide-free agriculture has not been established as an independent agricultural land use management form within Europe. There are initiatives to establish pesticide-free agriculture in various European countries. In Switzerland, the producer organization "IP-Suisse" has introduced a private public standard for pesticide-free wheat cultivation. Swiss wheat producers who are members of the producer organization can participate in this pesticide-free wheat production scheme (www.ipswiss.ch; Finger & Möhring, 2022; Möhring & Finger, 2022). In Germany, there are currently individual private initiatives (e.g., KraichgauKorn®; KraichgauKorn, 2021) that practice agriculture without synthetic chemical pesticides.

Pesticide-free agriculture gains in relevance as a subject of research in agricultural science (Jacquet et al., 2022). Scientific research projects are underway to examine the potential of pesticide-free agriculture as a supplement to established land use management forms (e.g., University of Hohenheim, 2023).

No claim for products from pesticide-free agriculture is available on the German food market. However, available studies show that the lack of a label is a key barrier to the purchase of pesticide-free food from the consumer's perspective (Hayati et al., 2017). While testing approaches for the establishment of pesticide-free agriculture, the development of a consumer-oriented product labelling is also important. It is essential that the information provided via the claim is understood by consumers. This is a prerequisite for an informed purchasing decision (Ammann et al., 2023; Delmas, 2010). In addition, the labelling must allow correct conclusions to be drawn as to what it stands for (Grunert, 2011).

The aim of the present study is to examine how different claims for vegetables from pesticide-free agriculture are evaluated by consumers in terms of their understandability and their fit with the land use management form addressed, and to what extent they are perceived as an aid in the purchase decision for vegetables. In the present study, vegetables were selected as an exemplary product group, as the absence of pesticides or pesticide residues in unprocessed foods, such as vegetables, is particularly important to consumers (Epp et al., 2010). Similar to the study by Mameno et al. (2021), the present study distinguishes between approach-based[1] and outcome-based[2] claims. Three included approach-based claims refer to the absence of pesticides as a central characteristic of the land use management form, as there are: "pesticide-free", "grown without synthetic chemical plant protection products" and "grown without pesticides". The four outcome-based claims focus on sustainability-related consequences of the pesticide renunciation and are worded as follows: "for protection of the diversity of animal and plant species", "for protection of the environment", "for protection of insects" and "for protection of bees".

Available studies focused on the consumer evaluation of approach- and outcome-based claims on insecticide (neonicotinoid) avoidance and the associated sustainability-related consequences. The avoidance of pesticides in general was not considered. In addition, the available studies relate to (flowering) plants and not to food (Wollaeger et al., 2015; Rihn & Khachatryan, 2016). Accordingly, the originality of the presented study lies in its evaluation of seven different approach- and outcome-based claim variants for food products within a pesticide-free, but mineral fertilizers using land use management form by consumers in one survey experiment using a split sample design.

The study provides an insight into the claim preferences of consumers for vegetables from pesticide-free agriculture. The insights gained are important for actors in the agricultural sector and the food industry as well as for food-related consumer research.

State of research

State of research on pesticide-free food: An overview

Looking at the consumer studies on pesticide-free food available to date, there are various studies on willingness to pay. For different consumer segments, there is an additional willingness to pay for both pesticide-free plant-based foods (e.g., Boccaletti & Nardella, 2000; Traoré et al., 2023) and animal-based foods (e.g., Wendt & Weinrich, 2023) in comparison to conventional product alternatives. It is also shown that the additional willingness to pay for pesticide-free food products compared to conventional product alternatives varies depending on the processing degree (Nitzko et al., 2024).

[1] In the present article, the term "claims on pesticide avoidance" is used synonymously for approach-based claims.

[2] In the present article the term "claims on (sustainability-related) consequences of pesticide avoidance" is used synonymously for outcome-based claims.

Using the example of apples, a study by Farías (2020) shows that consumers report a higher perceived quality, value, and purchase intention for products with a pesticide-free label compared to unlabeled alternatives. It is also clear that a pesticide-free label in combination with specific information on the harmful effects of pesticides has a stronger positive effect on perceived product quality, value, and purchase intention than pesticide-free labels in combination with general information on the harmful effects of pesticides.

Two studies compare the willingness to pay for organic products, pesticide-free products, and conventional products. Bernard and Bernard (2010) show for potatoes and sweet corn that consumers have an additional willingness to pay for organic and pesticide-free product variants over conventional products. The additional price for the pesticide-free product variant is lower than the additional price for the organic variant. Using the example of green tea, Zheng et al. (2022) show that a higher price would be paid for the organic variant compared to the average price for green tea. However, the willingness to pay for tea labelled as pesticide-free is lower than the average price for green tea.

Other available consumer studies compare pesticide-free labels and various other labels. The example of dried dates shows the highest willingness to pay for product alternatives with a pesticide-free label compared to variants with a GMO-free label and a label on origin (Grebitus et al., 2018). In this context, Peschel et al. (2019) were also able to identify a consumer group with a specific preference for pesticide-free labels. A characterization of this segment in terms of personality traits shows that the level of conscientiousness is above the sample average and the level of openness below the sample average. A study by Edenbrandt et al. (2018) focused on the attributes of pesticide-free and genetically modified products. In general, bread made from genetically modified rye was rated negatively compared to bread made from traditional rye. However, if the bread made from genetically modified rye came from a pesticide-free land use management form, then this bread was rated more favorably than bread made from traditional rye from a conventional land use management form.

In the following, the state of research will be presented specifically for approach- and outcome-based claims for products produced without synthetic chemical pesticides in terms of understandability, the fit of claim and agricultural land use management form, as well as the evaluation of support in the purchase decision.

Understandability of pesticide- and sustainability-related claims

A prerequisite for an informed purchase decision based on product claims is that the claims are correctly understood by consumers (Ammann et al., 2023; Grunert et al., 2014). This is the only way to reduce the information asymmetry between manufacturers and consumers (Delmas, 2010). Misinterpretations can result in an undesirable influence on food choices that are not in line with actual (sustainability-related) consumer preferences (Messer et al., 2017).

Regarding pesticide-related labelling, a study by Anderson et al. (1996) with products from integrated pest management shows that this approach was only known to 19% of the respondents. If a definition was given, then a proportion of 85% expressed a willingness to try products from integrated pest management. A study by Marette et al. (2012) also included the approach of integrated pest management. Regarding the labelling of the products, the authors used the general characteristic of "pesticide reduction". For apples with the claim "few pesticides", an additional willingness to pay compared to conventionally produced fruit could be demonstrated.

Regarding environmental claims, a French study used the example of wine to record consumer associations with the label "Haute valeur environnementale" (= high environmental value). The agricultural land use management form behind this label is characterized, among other things, by a reduced use of pesticides. A high proportion of respondents was unaware of this label and the pesticide reduction associated with this agricultural land use management form (Ginon et al., 2014).

Two available consumer studies include both approach- and outcome-based claims. A study by Wollaeger et al. (2015), using the example of flowering plants cultivated without neonicotinoids, shows that the claim "neonicotinoid-free" tends to be rejected. One possible reason for this is that the neonicotinoid term was not understood by 56.6% of the respondents. The claim "bee-friendly" was evaluated most positively and generated the highest willingness to pay. The label was correctly understood by a large proportion of respondents. Rihn & Khachatryan (2016) also show for plants grown without neonicotinoids that the claim "bee-friendly" was preferred by 34% of consumers. Only 6% of respondents preferred the claim "neonic-free", which is also attributed to the lack of familiarity with the neonic term.

The fit between claims and the agricultural land use management form behind them

It is essential that consumers can draw conclusions about what a food claim stands for (Grunert, 2011). So far, few studies have explicitly assessed the fit between food-related claims and the agricultural land use management forms behind them.

Regarding environmental claims, the study on wine by Ginon et al. (2014) cited above shows that consumers rarely spontaneously associate the label "Haute valeur environnementale" (= high environmental value) with pesticide avoidance (7.8% of the mentions related to the category "without chemical products/additives"). Regarding claims that address the protection of bees/pollinator insects (e.g., "bee-friendly"), a study by Khachatryan & Rihn (2018) shows that 40.9% of respondents consider "pesticide-free" to be a pollinator-friendly characteristic of plants.

The perception of claims as an aid to food purchasing

For product claims to have an influence on food-related purchase decisions, they must be seen by consumers as a relia-

ble aid for a sustainable purchase decision (Grunert, 2011). So far, no consumer studies are available that explicitly ask about the perception of claims as an aid in food purchasing. On the one hand, studies on willingness to buy and willingness to pay can provide indications of the relevance of claims. On the other hand, studies can be consulted that use eye tracking to record the visual attention that claims receive in the process of the choice decision.

A higher willingness to buy apples labelled "pesticide-free" compared to unlabelled alternatives is shown in a consumer study by Farías (2020). Grebitus and van Loo (2022) used the method of eye tracking in their consumer study and showed, using dates as an example, that the claim "pesticide-free" received the highest attention compared to GMO-free and origin-related claims.

Chen et al. (2018) investigated consumer preferences for various sustainability-related claims using strawberries as an example. Claims on agricultural production practices (reduced pesticides, less fertilizer use) and claims on sustainability-related effects (reduced negative impact on soil, air, and water) were included. For all sustainability-related claims, there was a higher willingness to pay compared to conventional products. The claim "reduced pesticides" generated the highest willingness to pay compared to all other claims. A study by Gatti et al. (2022) examined consumers' willingness to pay for coffee labelled with different sustainability attributes. The highest willingness to pay is shown for the organic label, followed by coffee with a pesticide-free label (followed by bird-friendly and shade-grown). Using the eye tracking method, van Loo et al. (2015) show that sustainability attributes communicated via labels on foods that are significant for consumers, receive more frequent and longer visual attention in the selection situation. In addition, product variants with subjectively meaningful claims generate a higher willingness to pay.

A review of the current state of research shows that, on the one hand, there are few studies that compare the understandability of different claims on pesticide avoidance and claims on consequences of pesticide avoidance. The studies described (unlike the present study) do not refer to the avoidance of pesticides in general, but to insecticides (neonicotinoids). In addition, the products included were not food products but (flowering) plants (Wollaeger et al., 2015; Rihn & Khachatryan, 2016). Likewise, there is a lack of studies that examine the fit between claims and the agricultural land use management form that avoids pesticides. Studies available to date on the willingness to buy/pay for products, and on the recording of visual attention in the process of product selection, allow conclusions to be drawn on the extent to which claims support the process of the purchase decision. There is also a lack of studies that directly investigate the extent to which different claims on pesticide avoidance and on sustainability-related consequences of pesticide avoidance support the purchase decision.

In this light, the present study will use the example of vegetables to evaluate different claims on pesticide avoidance and consequences of pesticide avoidance from the consumer's point of view. It investigates which claim preferences exist among consumers regarding the understandability of the claims and the fit between the claim and the agricultural land use management form behind it. In addition, it examines to what extent the various claims are perceived as an aid in the purchase decision for vegetables.

Materials and methods

Data collection and sample description

In November 2022, 1,100 German consumers were recruited from the online access panel of a commercial provider. Only data from participants who completed the questionnaire to the end were taken into account. The raw data set was subjected to data cleaning. All participants with a too short response time were excluded (for this purpose, the average response time was determined for the total sample and all participants whose response time was less than one third of the average response time were excluded). After data cleaning, a sample of 953 consumers was used for the analyses. A quota sample was collected. Here, gender, educational level, and age functioned as quota-forming characteristics. Data from the Federal Statistical Office of Germany (2014; 2019; 2022) was used to determine the distribution of the characteristics in the German population.

Table 1 shows the representative percentage and the percentage frequencies calculated for the sample for the quota-forming characteristics. The frequencies calculated for the sample in the individual categories of the quota-forming characteristics deviate from the representative frequencies by a maximum of 1.62%.

Questionnaire

An online questionnaire was used to collect the data. The online version of the questionnaire was programmed using the EFS Survey software (Unipark, Tivian XI GmbH) (Unipark, 2023). As an introduction, socio-demographic aspects were queried. The total sample was then randomly divided into seven sub-samples (split-sample design). A random trigger (a feature provided by the EFS Survey software used) was used to randomly allocate the participants to the previously defined number of seven independent groups. For this purpose, the programme "rolled" at the start of the survey and assigned each participant a random number between 1 and 7. The activated function "aim for equal distribution" ensured equal distribution among the seven groups (Hanover University of Music, Drama and Media, 2020).

Based on a literature research, the authors of the article wrote an information text on the cultivation of vegetables. Each sub-sample received the introductory information text on three ways of growing vegetables: (a) conventional farming, where mineral fertilizers and pesticides are used, (b) organic farming, where mineral fertilizers and pesticides are not used and alternative measures are taken instead, and (c) an innovative land use management form, where mineral fertilizers are used and pesticides are not used (alternative measures are taken instead). In this context, the text also stated that the avoidance of pesticides contributes to the protection of the environment and the biodiversity of

Table 1. Percentage of frequencies in the consumer sample as well as representative percentage of frequencies according to the data of the Federal Statistical Office of Germany regarding the variables age, gender, and education

Characteristic	Percentage of frequencies in the sample (%)	Representative percentage of frequencies according to the Federal Statistical Office of Germany (%)
Gender[a]		
Male	47.85	49.22
Female	52.15	50.78
Age groups[b] (in years)		
18–29	15.84	15.61
30–39	16.05	16.37
40–49	16.05	16.15
50–59	21.41	21.68
60–69	20.78	20.38
70–75	9.86	9.80
Education[c]		
Still in school	0.84	0.99
Without school leaving certificate + certificate of secondary education	27.49	29.02
General certificate of secondary education	32.63	32.58
Advanced technical college entrance qualification/university entrance diploma	39.03	37.41

Federal Statistical Office of Germany [a](2022), [b](2014), [c](2019)

plants/animals (cf. Box). All participants were then informed that there is currently no labelling on food for the latter land use management form. Subsequently, each sub-sample was shown one of seven claims (cf. Table 2). Three of the claims directly addressed the avoidance of pesticides as a central characteristic of the agricultural land use management form (approach-based claims). Four claims referred to the consequences of pesticide avoidance (outcome-based claims). The claims were created by the authors of the study.

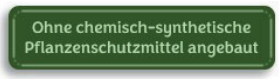
Although the terms "pesticides" and "plant protection products" can be clearly distinguished from each other in a scientific sense, they are often used interchangeably in public discussions and everyday language in the German-speaking areas (EFSA, 2023a; Lower Saxony State Office for Consumer Protection and Food Safety, 2023). Pesticides are substances used to kill/control pests (EFSA, 2023b). Pesticides can be divided into plant protection products (products for the protection of plants) and biocides (products for the protection of humans and animals) (EU Directive 2009/128/EC). Accordingly, pesticides are the active ingredients in plant protection products and biocides, giving them their pesticidal effect (NABU, 2020). Due to the synonymous use of the two terms "pesticide" and "plant protection product", both terms were taken into account in the formulation of the claims on pesticide avoidance in order to examine possible differences with regard to existing consumer preferences.

Regarding the outcome-based claims, reference was made to significant sustainability-related consequences of pesticide use or the avoidance of these consequences by not using pesticides. For this purpose, a literature review was conducted in advance, and the following aspects were identified as significant consequences of not using pesticides and were included in the study: protection of biodiversity (diversity of animal and plant species) (e.g., Tang et al., 2021; Geiger et al., 2010), protection of the environment (Tudi et al., 2021; Ali et al., 2021), protection of insects (Sonoda et al., 2011; Forister et al., 2019; van der Sluijs, 2020) and, in particular, protection of bees (Sanchez-Bayo & Goka, 2014; Whitehorn et al., 2012).

Following the presentation of the claim, the participants in each sub-sample were asked to evaluate the claim variant presented to them in terms of three aspects. Before the development of the questions, a literature research was conducted on the topic of the study. As no questionnaires were available that allowed the measurement of the aspects of interest, the items were constructed by the authors of the study. The response scales (verbal anchors) were developed based on the recommendations of Mummendey & Grau (2018).

The participants were asked to indicate how understandable they thought the claim was (response scale: 1 = *not understandable*, 2 = *little understandable*, 3 = *moderately understandable*, 4 = *quite understandable*, 5 = *very understandable*). In addition, it was assessed to what extent the claim fits the described agricultural land use management form from the respondents' point of view (response scale: 1 = *not suitable*, 2 = *little suitable*, 3 = *moderately suitable*, 4 = *quite suitable*, 5 = *very suitable*). The respondents were also asked to assess the extent to which they thought the claim would help them in their decision to buy vegetables (response scale: 1 = *would not help at all*, 2 = *would probably not help*, 3 = *would perhaps help*, 4 = *would quite probably help*, 5 = *would definitely help*) (cf. Fig. 2).

Table 2. Overview of the subsamples and the claims presented in each case

Split	Claim content	Kind of claim	Size of the split	Claim
Split 1	For the protection of animal and plant species diversity	Outcome-based claim	135	
Split 2	For the protection of the environment	Outcome-based claim	137	
Split 3	For the protection of insects	Outcome-based claim	146	
Split 4	For the protection of bees	Outcome-based claim	121	
Split 5	Pesticide-free	Approach-based claim	138	
Split 6	Grown without synthetic chemical plant protection products	Approach-based claim	136	
Split 7	Grown without pesticides	Approach-based claim	140	

Source: own illustrations

The developed questionnaire was subjected to a pre-test before the main study (employees and students of the university were involved). The pre-test served to ensure that the information text and the items were understandable and that the claims were designed appropriately. In addition, the pre-test ensured that no technical problems occurred when answering the online questionnaire (Converse & Presser, 1986; Porst, 1998).

Until now, there have been no claims available on the German food market for labelling vegetables grown without pesticides. Available studies on consumer preferences for different labels often use discrete-choice experiments/conjoint analyses. The willingness to buy or willingness to pay is usually recorded (e.g., Wollaeger et al., 2015; Chen et al., 2018; Gatti et al., 2022). Different claim alternatives are presented to the respondents and the most favored option is selected (Auspurg & Liebe, 2011). The aim of the present study is to measure the suitability of each individual claim as an indicator for the introduced land use management form. In this light, the split sampling method is used in this study. This method makes it possible for each participant to evaluate one claim alternative (independently of other claim variants) in detail regarding the aspects of interest. This will provide a more differentiated insight into the consumer evaluation of the various claim alternatives in a phase in which a "pesticide-free" label is not yet regularly available.

Statistical analyses

The SPSS 26 program was used for data analysis. Frequency counts were carried out to evaluate the data on socio-demographics. Analyses of variance (ANOVAs) were carried out to examine the extent to which the evaluation of the various claims differed in terms of understandability, fit with pesticide-free agriculture, and perception as an aid in vegetable-related purchasing decisions. When there were significant differences between the sub-samples, further post hoc tests were carried out.

ANOVA is an established statistical analysis method for comparing independent groups in relation to (quasi-)metrically scaled dependent variables (Field, 2013). This statistical method was therefore used to examine the extent to which the formed consumer groups differ from one another in terms of the evaluation of the claims.

A χ^2-test was used to test whether the seven sub-samples formed, differ regarding age, gender, and education. There were no significant differences between the groups (cf. supplementary Table S).

Results

The understandability of the claims

For the different sub-samples, the understandability of the claims was between "moderately understandable" and "quite understandable". There were significant differences between the subsamples. The claim "for the protection of the environment" was rated as significantly less understandable than the claims "pesticide-free", "grown without synthetic chemical plant protection products", and "grown without pesticides". In addition, the claim "for the protection of insects" was considered less understandable than the claim "grown without pesticides" (cf. Table 3).

Vegetables can be grown in different forms of agriculture. Usually, a distinction is made between conventional farming and organic farming.

When vegetables are grown in conventional agriculture, mineral fertilizers are used to provide the vegetables with the nutrients they need to grow. In addition, synthetic chemical pesticides are used to protect the vegetables from pests and diseases and to control weeds.

When growing vegetables in organic farming, no mineral fertilizers are used. Instead, alternative measures are taken to provide the vegetables with the nutrients they need to grow (e.g., use of natural fertilizers such as manure from animals and composts). Furthermore, no synthetic chemical pesticides are used. Instead, alternative measures are taken to control weeds (e.g., hoeing of weeds) and to protect the vegetables from pests (e.g., use of natural enemies) and diseases (e.g., selection of resistant varieties).

In the following, we would like to introduce you to another, hitherto little-known, form of agriculture in which vegetables can also be grown. In this form of agriculture, mineral fertilizers are used to provide the vegetables with the nutrients they need to grow. Synthetic chemical pesticides are not used. Instead, alternative measures are taken to control weeds (e.g., hoeing of weeds) and to protect the vegetables from pests (e.g., use of natural enemies) and diseases (e.g., selection of resistant varieties). In addition, modern technologies are used (e.g., robotics, automation technologies, e.g., to avoid nutrient losses). Since the use of synthetic chemical pesticides can also harm animals and plants that are not detrimental to agriculture, not using synthetic chemical pesticides contributes to the protection of plant and animal biodiversity. In addition, it can contribute to the protection of the environment, as the negative consequences for soil, groundwater, air, and water bodies associated with the use of synthetic chemical pesticides are eliminated.

There is still no labelling for vegetables from this hitherto little-known form of agriculture. In the following, we would like to present a possible claim.

Box. Information text

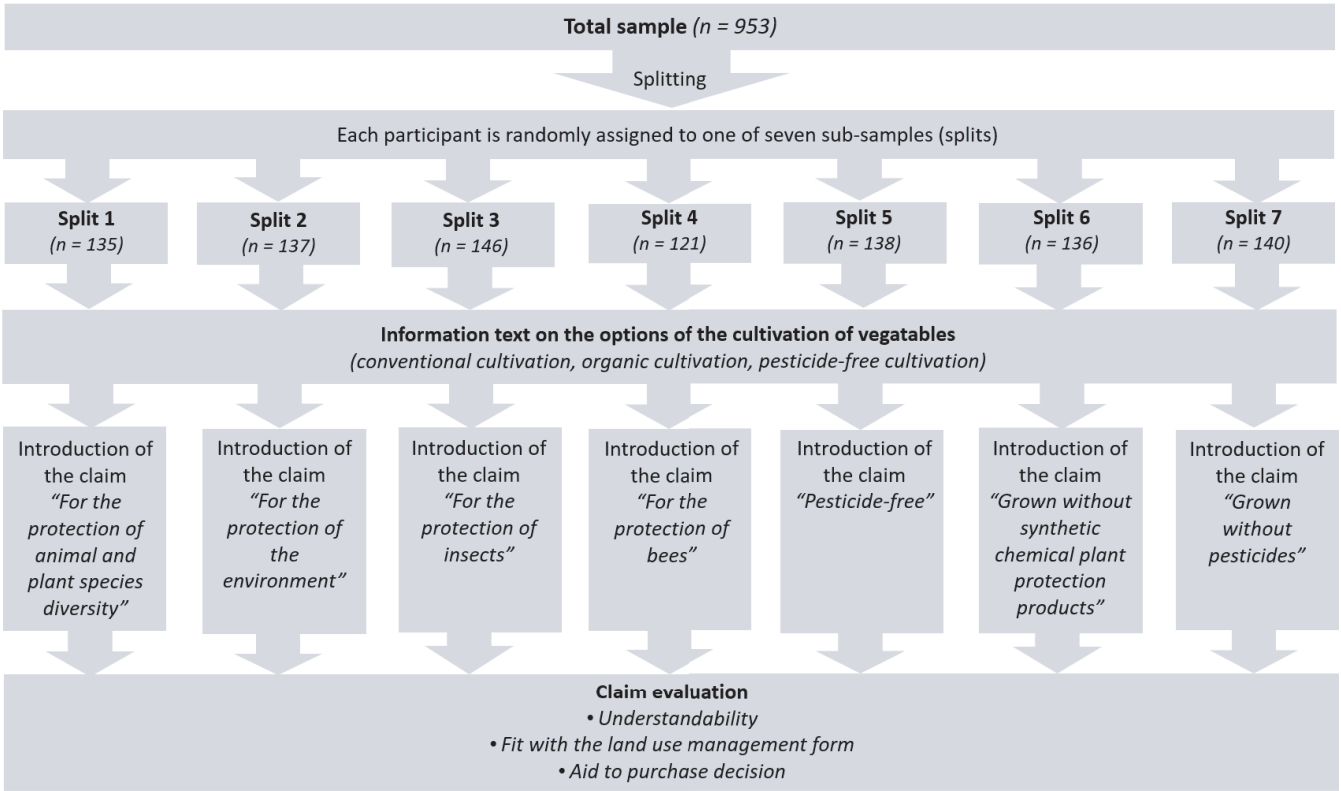


Fig. 2. Split-sample design: Overview

Table 3. Results of the variance analyses in relation to the evaluation of the different claims

Item	Split 1[1] (a) (M, SD)	Split 2[2] (b) (M, SD)	Split 3[3] (c) (M, SD)	Split 4[4] (d) (M, SD)	Split 5[5] (e) (M, SD)	Split 6[6] (f) (M, SD)	Split 7[7] (g) (M, SD)	Results of ANOVAs
How understandable is the claim?[8]	3.67 (1.03)	3.50 (.97)$^{b<e, b<f, b<g}$	3.63 (.99)$^{c<g}$	3.69 (.94)	3.91 (.92)$^{b<e}$	3.90 (.96)$^{b<f}$	3.99 (.98)$^{b<g, c<g}$	F = 4.80, p = .000
To what extent does the claim fit the type of farming described?[9]	3.64 (.95)	3.40 (.98)$^{b<e, b<f, b<g}$	3.52 (.93)$^{c<f}$	3.50 (1.00)$^{d<f}$	3.79 (.79)$^{b<e}$	3.87 (.90)$^{b<f, c<f, d<f}$	3.81 (.81)$^{b<g}$	F= 5.38, p = .001
To what extent would the claim provide guidance in the purchase decision for vegetables?[10]	3.33 (1.11)$^{a<e, a<g}$	3.23 (1.07)$^{b<e, b<f, b<g}$	3.28 (1.06)$^{c<e, c<g}$	3.43 (1.07)$^{d<e}$	3.91 (.95)$^{a<e, b<e, c<e, d<e}$	3.63 (1.01)$^{b<f}$	3.74 (1.07)$^{b<g, c<g}$	F = 8.19, p = .001

[1] Claim "for the protection of animal and plant species diversity", [2] claim "for the protection of the environment", [3] claim "for the protection of insects", [4] claim "for the protection of bees", [5] claim "pesticide-free", [6] claim "grown without synthetic chemical plant protection products", [7] claim "grown without pesticides", [8] Complete item: "How understandable is the claim in your view?", response scale: 1 = ***not understandable***, 2 = ***little understandable***, 3 = ***moderately understandable***, 4 = ***quite understandable***, 5 = ***very understandable***, [9] Complete item: "In your view, to what extent does the claim fit with the form of agriculture described?", response scale: 1 = ***not suitable***, 2 = ***little suitable***, 3 = ***moderately suitable***, 4 = ***quite suitable***, 5 = ***very suitable***, [10] Complete item: "In your view, to what extent would this claim provide assistance in making purchase decisions for vegetables?", response scale: 1 = ***would not help at all***, 2 = ***would probably not help***, 3 = ***would perhaps help***, 4 = ***would quite probably help***, 5 = ***would definitely help***, [a, b, c, d, e, f] The subscript letters indicate significant differences of group means in the post hoc test ($p < 0.05$).

The fit between the claim and the agricultural land use management form behind it

Regarding the question of the extent to which the respective claim fits the agricultural land use management form described, the overall ratings were between "moderately suitable" and "quite suitable". There were significant differences between the subgroups. The claim "for the protection of the environment" was seen as significantly less appropriate than the claims "pesticide-free", "grown without synthetic chemical plant protection products" and "grown without pesticides". In addition, the claim "for the protection of bees" was considered significantly less appropriate compared to the claim "grown without synthetic chemical plant protection products" (cf. Table 3).

The perception of the claim as an aid to buying vegetables

Overall, the various claims would "possibly" to "quite probably" provide assistance in the purchase decision for vegetables. Significant evaluation differences were shown between the sub-samples. The claims "for the protection of insects" and "for the protection of animal and plant species diversity" would provide significantly less assistance in the purchase decision than the claims "pesticide-free" and "grown without synthetic chemical plant protection products". The claim "for the protection of the environment" would provide less assistance in the purchase decision than the claims "pesticide-free", "grown without synthetic chemical plant protection products", and "grown without pesticides". The claim "for the protection of bees" would be less helpful in the purchase decision than the claim "pesticide-free" (cf. Table 3).

All in all, the respondents prefer the middle answer categories regarding the evaluation of understanding, the fit between claim and land use management form, as well as the perception of the claims as supporting the vegetable-related purchase decision. In this context, the response bias of the error of central tendency becomes clear. This is not a random error, but as systematic error. Respondents tend to choose the middle response categories/response ranges unexpectedly often. This can result in reduced item variance or bias. The background for the error of central tendency, may be insufficient familiarity with the subject of the study, the latter of which involves an innovative land use management form that has not been widely used to date (Jonkisz et al., 2012; Wirtz, 2019). It also becomes clear that the various claims on pesticide avoidance and the various claims on sustainability-related consequences of pesticide avoidance do not differ significantly from each other. In particular, the terms "pesticides" and "synthetic chemical plant protection products" were considered equally useful for approach-based claims. The different claim formulations ("...free" vs. "grown without.. . ") were also equally appropriate.

Discussion

Regarding an innovative land use management form that uses mineral fertilizers and avoids the use of pesticides, the present study tested how consumers evaluate different approach-based claims that (in different formulations) directly address the avoidance of pesticides. In addition, different outcome-based claims that refer to the sustainability-related consequences of pesticide avoidance were included.

In terms of understandability, it became clear that all included claims were considered to be moderately to quite understandable. Two claims on sustainability-related consequences of pesticide avoidance ("for the protection of the environment", "for the protection of insects") were rated as significantly less understandable than the claims on pesticide avoidance.

Studies that are already available also point to weaknesses regarding the understandability of outcome-based claims. Experts from the food sector consider product claims focusing on the sustainability-related consequences of food pro-

duction (e.g., environmentally friendly) to be rather vague in their meaning (Bhaskaran et al., 2006). Similarly, a focus group study with consumers revealed skepticism about general claims on sustainability-related effects (e.g., climate-friendly) (Sirieix et al., 2013).

Overall, the findings of the present study and the results of available studies (Bhaskaran et al., 2006; Sirieix et al., 2013) suggest that outcome-based claims (compared to approach-based claims) are less clear and offer greater scope for interpretation (D'Souza, 2004). This can result in misinterpretations regarding the sustainability-related impact of products (Messer et al., 2017). According to the findings of the present study, approach-based claims that address a very specific and delimited characteristic of the land use management form are considered more understandable by consumers.

All the claims included in this study are considered moderately to quite suitable for the land use management form. Significant differences can be found in the fact that individual claims on sustainability-related consequences of pesticide avoidance ("for the protection of the environment", "for the protection of bees") are considered to be significantly less suitable for the agricultural land use management form than the claims on pesticide avoidance.

If we look at the findings of available studies regarding the fit between claim and land use management form, the superiority of claims on pesticide avoidance over claims on sustainability-related consequences of pesticide avoidance also becomes clear. In a study by Ginon et al. (2014), the two labels on sustainability-related consequences of pesticide avoidance "L'abeille sentinelle d'environnement" (the sentinel bee of the environment) and "Haute valeur environnementale" (high environmental value) were included. Each label represents a land use management form with reduced pesticide use. The two claims are rarely spontaneously associated with a pesticide reduction. In contrast, in a study on integrated farming by Marette et al. (2012), the pesticide reduction ("few pesticides") was used as a central characteristic of the land use management form for product labelling (in the sense of an approach-based claim). Consumers honored this product claim with an additional willingness to pay compared to conventional alternatives.

Overall, the findings of the present study suggest that highlighting the central characteristic of the pesticide-free land use management form is seen as more appropriate from the consumer's perspective than mentioning the associated sustainability-related consequences, such as the protection of the environment or of bees.

All of the claims included would "perhaps" to "quite probably" provide assistance in the purchase decision for vegetables. The existing significant differences indicate that the claims on pesticide avoidance, such as "pesticide-free", "grown without synthetic chemical plant protection products" or "grown without pesticides", would be more likely to help with the purchase of vegetables than the claims on sustainability-related consequences of pesticide avoidance. The findings of existing studies are also consistent with this. In a study by Petrescu et al. (2020), consumers were asked to spontaneously indicate which cues/signals they consider when including the environmental impact of food in their choice decision. Pesticide use was among the most frequent mentions, while general environmental impact and loss of biodiversity were mentioned less frequently. Similarly, a study by Tait et al. (2019), using wine as an example, shows that different sustainability attributes had different effects on wine choice. Thus, the management of pests/diseases was of significantly higher relevance than biodiversity management. In addition, Gatti et al. (2022) used the example of coffee to show that consumers have a higher willingness to pay for coffee labelled as "pesticide-free" than for products with a biodiversity protection label ("bird-friendly").

A possible explanation for the fact that claims on pesticide avoidance are considered more helpful for the purchase decision than claims on sustainability-related consequences could be the "negativity bias". According to this notion, negative claims (i.e., claims that signal the absence of something negative/harmful) have a greater effect on a person's perception and behavior than positive claims (e.g., claims about sustainability-related benefits) (Salnikova & Stanton, 2021).

The results of the study have implications for sustainability communication. There is a preference for claims on pesticide avoidance over claims on sustainability-related consequences of pesticide avoidance. This result can be seen as critical regarding the relevance of sustainability-related claims for food choice. The avoidance of pesticides is not a sufficient condition for sustainability. Nevertheless, such claims would have a stronger influence on consumers' food choices than claims with a specific reference to positive sustainability-related consequences.

There is a need for further research on the topic under consideration. The development of adequate labelling for products produced without synthetic chemical pesticides is highly relevant. A consumer-friendly labelling is a prerequisite for sustainable and informed food choices. On the one hand, it would be useful to extend the study of consumer claim preferences to further groups of foods produced without pesticides. All in all, it would also be useful to investigate foods with different processing degrees that contain pesticide-free ingredients. Available studies show that consumers are particularly concerned about pesticide residues in unprocessed/less processed foods (Epp et al., 2010). Similarly, it would be expedient to examine the consumer relevance of pesticide-free labelling for moderately to highly processed foods as well.

Limitations of the study

The present study only includes German consumers. In light of the importance of the renunciation of pesticides in various European countries (Jacquet et al., 2022), the establishment of a pesticide-free land use management form would also be useful for other European countries. Further studies could compare the claim preferences of consumers from different European countries. In addition, other methodological approaches for measuring consumer preferences could be included in follow-up studies (e.g., choice experiments).

The consumer evaluation of the claims was recorded only for vegetables, not for food in general. In addition, only three items were used to evaluate the claims. The evaluation of the claims using only three items provides merely an initial insight into the consumer's perspective. Additional questions would have been useful to gain more comprehensive insights. Another option would have been, for example, the inclusion of a semantic differential (Osgood et al., 1957). This would have allowed the characteristics that consumers attribute to the claims to be recorded in a more differentiated way.

In addition, the inclusion of the recorded socio-demographic variables in the data analyses (i.e., their influence on consumer perceptions and preferences) could have provided further insights. In general, the present study is limited to recording consumer perceptions and intentions. Actual purchasing behavior was not accessed. Accordingly, a hypothetical bias may exist. Based on the data collected, it is difficult to estimate the actual influence of the claims on consumers' food choices. This would require recording the non-hypothetical willingness to pay or purchase behavior (Müller et al., 2009).

In the discussion of the results, only assumptions can be made regarding the background for the participants' response behavior/evaluations. The collection of data to analyze the background factors of the response behavior would have been useful. A qualitative approach would be useful in future studies. This could be used, for example, to measure spontaneous consumer associations with various claims for food from a pesticide-free land use management form (without predefining information on the cultivation system).

As already mentioned, the study is limited to German consumers. This restricts the generalizability of the results to other regions with different cultural backgrounds or different consumer preferences. This study is also a cross-sectional survey. The dynamics and evolving nature of consumer attitudes over time could not be captured in this way.

In addition, the sample was recruited via an online access panel. The aspect of self-selection of the participants must be taken into account here. This means that the initiative for participation in the online access panel in general and in the individual surveys comes from the participants. As a result, certain sub-groups (e.g., participants with a special interest in the topic of the survey) may be over-represented in the sample (Göritz, 2003).

Further, this study only includes claims that refer to the avoidance of pesticides and the sustainability-related consequences of not using pesticides. Other claims that also represent sustainable land use management forms (e.g., organic agriculture) were not taken into account.

Another limitation relates to the information text presented on the options for the cultivation of vegetables (cf. Box). Some of the terms used to describe the options were not neutral and included a judgement. This type of phrasing may have contributed to a distortion of the results. In addition, only the sustainability-related consequences of the pesticide-free land use management form were presented in the information text. In the description of conventional and organic farming, no statements were made on the resulting sustainability-related consequences of the land use management forms. The description of the different land use management forms should have been more consistent here. Overall, it cannot be ensured in the presented study that the existing differences between the land use management forms were fully understood on the basis of the information text. It would have been useful to provide comprehension/knowledge questions on the various land use management forms after the information text was provided. It would have been appropriate to evaluate the claims for pesticide-free agriculture only after the questions had been answered correctly.

Conclusions

The present study analyzed how German consumers evaluate various claims on pesticide avoidance and sustainability-related consequences of pesticide avoidance using the example of vegetables.

For vegetables produced without pesticides, the present study generally shows that the labelling of the products is seen as beneficial by the consumers. There is a preference in the middle range for all claims included. From the consumer's point of view, all claims included are "moderately" to "quite understandable", "moderately" to "quite appropriate" to the agricultural land use management form behind them, and "perhaps" to "probably helpful" in the purchase decision for vegetables.

Regarding the surveyed aspects, there is no consistent pattern of differences between the claims on pesticide avoidance and the claims on sustainability-related consequences of pesticide avoidance. If significant differences do occur, then individual claims on pesticide avoidance are rated as more understandable, more appropriate to the land use management form and more helpful for the purchasing decision than individual claims on sustainability-related consequences of pesticide avoidance.

The findings of the study allow conclusions to be drawn for the labelling of vegetables from pesticide-free agriculture. For the actors of the agricultural and food sector, it is evident regarding the marketing of vegetables grown without pesticides that an appropriate claim, which is rarely found on the market so far, is a sensible and useful option from the consumer's point of view. The product labelling can contribute to supporting consumers in more sustainable food consumption and can support the sustainable production of food/agricultural products.

Although individual claims on pesticide avoidance are perceived as more beneficial than individual claims on sustainability-related consequences of pesticide avoidance, no clear conclusions can be drawn in this regard.

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Conflicts of interest

The authors declare that they do not have any conflicts of interest.

Data availability

The data are available from the first author, upon request.

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Supplementary information

Table S. Results of the comparison of the splits regarding age, gender, and education

Characteristic	Split 1[a] (n = 135)	Split 2[b] (n = 137)	Split 3[c] (n = 146)	Split 4[d] (n = 121)	Split 5[e] (n = 138)	Split 6[f] (n = 136)	Split 7[g] (n = 140)	Results of χ^2 test
Gender								$\chi^2 = 6.39$; p = .381
Male	41.5%	54.0%	45.9%	49.6%	50.0%	50.7%	43.6%	
Female	58.5%	46.0%	54.1%	50.4%	50.0%	49.3%	56.4%	
Age groups (in years)								$\chi^2 = 26.56$; p = .646
18–29	29.7%	17.5%	14.4%	12.4%	15.2%	10.3%	20.0%	
30–39	15.6%	13.9%	17.8%	19.8%	13.8%	14.0%	17.9%	
40–49	17.0%	11.7%	15.1%	16.5%	20.3%	17.6%	14.3%	
50–59	20.0%	24.1%	18.5%	19.0%	20.3%	25.7%	22.1%	
60–69	20.0%	23.4%	19.2%	24.0%	18.8%	23.5%	17.1%	
70–75	6.7%	9.5%	15.1%	8.3%	11.6%	8.8%	8.6%	
Education								$\chi^2 = 21.85$; p = .239
Still in school	2.2%	0%	1.4%	0%	0%	0%	2.1%	
Without school leaving certificate + certificate of secondary education	29.6%	29.6%	30.1%	25.6%	21.7%	30.1%	25.0%	
General certificate of secondary education	33.3%	31.4%	34.9%	35.5%	33.3%	33.8%	26.4%	
Advanced technical college entrance qualification/university entrance diploma	34.8%	38.7%	33.6%	38.8%	44.9%	36.0%	46.4%	

[a] Claim "for the protection of animal and plant species diversity", [b] claim "for the protection of the environment", [c] claim "for the protection of insects", [d] claim "for the protection of bees", [e] claim "pesticide-free", [f] claim "grown without synthetic chemical plant protection products", [g] claim "grown without pesticides"