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Implications to reduce food waste and enhance sustainable food supply: results from a choice experiment with professionals and lay consumers

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Background: Today's consumers are accustomed to purchasing visually flawless fruits and vegetables from a globalized market. However, it remains unclear whether they are willing to buy produce with visual imperfections to reduce food waste. This choice experiment investigated which product attributes influence consumers' willingness to purchase "imperfect" apples. The analysis compared professionals from the food and health sectors with lay consumers.

Methods: In early 2024, a nationwide online survey was conducted in Germany, including a choice experiment implemented using Sawtooth software. The experiment assessed preferences for various apple attributes: regional origin, cultivation method, price per kilogram, promotional claims, and appearance. Responses from professionals in the food and nutrition sectors were compared with those from laypersons across different age groups. Latent class analysis (LCA) was applied to identify consumer segments based on the relative importance of these attributes in their purchasing decisions.

Results: A total of 118 individuals participated in the study (74.6% female). The majority were aged 20–29 years (35.9%), and 14.1% were aged 60 years or older. More than half (55.1%) reported working in the food or health sector. LCA revealed four distinct consumer segments: (1) multi-criteria-focused, (2) sustainability-focused, (3) price-driven, and (4) claim/appearance-focused. Professionals were predominantly classified as rationalists, assigning importance to all attributes except promotional claims. Accordingly, they were underrepresented in the claim/appearance segment. Female participants were most prevalent in the sustainability-focused segment, while male participants were more frequently found in the price-driven segment.

Conclusion: Efforts to promote the purchase of visually imperfect produce should be tailored to specific target groups. Consumers oriented toward price, regionality, or sustainability may be more receptive to purchasing such products. Professionals in the food and health sectors demonstrated a more comprehensive, multi-criteria-based approach to product evaluation, indicating that education remains a valuable strategy. These findings provide insight into consumer preferences and offer practical implications for food producers aiming

to develop more sustainable food systems. Future research could build on these results to further explore effective interventions for reducing food waste.

KEYWORDS

choice experiment, consumers' food choice, consumer segments, food waste, sustainability

Introduction

Food waste plays an increasing role considering the growing global population and actual world hunger, where one of 11 people was malnourished in 2023 (World Health Organisation, 2024). To meet global demand, agricultural production must expand by approximately 1.1% annually due to population growth (Alexandratos and Bruinsma, 2012). Furthermore, global food production represents the largest human-driven pressure on natural systems, threatening local ecosystems and the stability of the Earth's system (Willett et al., 2019). Given these challenges, a shift toward more sustainable food production is essential, including the holistic utilization of agricultural raw materials and the minimization of losses along the entire value chain.

In light of sustainability concerns, various initiatives have been launched to raise public awareness and relax regulations regarding the appearance of fruits and vegetables. At the European Union level, there is a commitment to achieve Sustainable Development Goal (SDG) Target 12.3, which aims to halve per capita food waste at the retail and consumer levels by 2030 and to minimize food losses throughout production and supply chains (United Nations, 2025). In Germany, the Federal Ministry of Agriculture, Food and Regional Identity (BMLEH) launched the initiative “Zu Gut für die Tonne” (English: “Too Good for the Bin”), which focuses on educating consumers about food waste across the entire supply chain (Lebensmittelverschwendung, o. J.). Another initiative from the Federal Center for Nutrition (BZfE) offers educational modules for primary school children, demonstrating alternative uses for imperfect fruits and vegetables.

The role of retailers in the acceptance of imperfect fruit should not be underestimated. Decades of marketing flawless products have shaped consumer expectations and created a mental “model” of perfection. They could achieve the opposite by expanding their range to include imperfect products, placing them strategically in a more visible place and informing shoppers transparently about the origin and quality of the products through advertising and clear labeling (inRiver PIM study, 2019; Louis and Lombart, 2018; Pfeiffer et al., 2021; Proveg International, 2022). Some of the major retail chains have already included imperfect fruit and vegetables in their range. Supermarket chains such as Rewe, Penny, Kaufland, and Edeka, as well as the French retailer Intermarché, have started offering “imperfect” fruits and vegetables at discounted prices alongside perfectly shaped produce. Companies such as etepetete, Rübenretter, and Die Krumme Gurke purchase fruits and vegetables from farmers that do not meet conventional market standards and deliver them directly to consumers in the form of fruit and vegetable boxes.

Attitudes and consumer behavior was evaluated by a survey conducted by the Nature Conservation Union (NABU) in 2014, which showed that more than 90% of respondents were willing to purchase “imperfect” fruits and vegetables. Approximately 49% would buy them if they were cheaper, and 42% would purchase them at the same price (NABU—Naturschutzbund, 2014). Price appears to be a decisive factor in the purchase of “imperfect” fruits and vegetables, with taste also being regarded as equally important by consumers.

Consumers' preferences for fresh produce, like apples, are influenced by various attributes that impact their willingness to purchase. Research has shown that consumers consider both intrinsic and extrinsic attributes when making buying decisions. Intrinsic attributes include factors like fruit size, variety, water core presence, and government certifications like green food labels, which signify food safety and eco-friendliness (Wang et al., 2022). Extrinsic attributes encompass commercial aspects such as price, packaging, branding, country of origin, and sustainability (Meike et al., 2022). These attributes play a significant role in shaping consumer choices and willingness to pay for fresh produce.

Studies have highlighted the importance of factors like sweetness, juiciness, crispiness, and appearance in influencing consumer preferences for apples (Meike et al., 2022). Additionally, the presence of organic labels and other certifications can impact consumer behavior significantly (Qu et al., 2023). Consumers often rely on search attributes (known before purchase) like price and package details, experience attributes (known after purchase) such as taste qualities, and credence attributes (unknown even after consumption) like organic labels to guide their purchasing decisions (Meike et al., 2022).

Overall, consumers are open to purchasing imperfect-looking products if they align with their preferences for taste, quality, and other important attributes. Understanding these consumer preferences is crucial for producers and retailers to cater to the evolving demands of the market effectively.

However, there are only a few studies that examine consumer purchasing behavior regarding these products in detail. Therefore, the aim of this study is to gain a deeper understanding of consumer behavior and the motivations behind purchasing “imperfect” fruits and vegetables in Germany. To achieve this, a hypothetical choice experiment using visual stimuli was conducted online to simulate a scenario in which consumers must indicate which of the shown apple product alternatives they would buy. A latent class choice analysis assessed the importances of different product attributes for various consumer groups, because consumers respond differently to product characteristics, and neglecting this fact could obscure valuable insights when only analyzing the preferences of the average consumer (Teuber et al., 2016). The ultimate goal is to identify

and profile consumer segments that can be effectively targeted when developing future strategies to reduce food waste in the fruit and vegetable sector. Additionally, the findings may influence product management strategies aimed at promoting “imperfect” fruits and vegetables.

Methods

Study design and data collection

Data collection for this cross-sectional study took place between November 2023 and April 2024. The online survey was developed as a virtual choice experiment. At the beginning of the questionnaire, participants were provided with an introductory information page outlining the purpose of the study, the voluntary nature of participation, and the anonymous handling of all collected data. Participants were explicitly informed that they could discontinue participation at any time without any consequences.

Informed consent was obtained electronically prior to participation. Specifically, participants were required to actively confirm their consent by clicking an “I agree” button before proceeding to the questionnaire. Only after this confirmation were they able to access the survey, ensuring that participation was fully informed and voluntary. Due to the fact that the survey was anonymous, did not involve the collection of sensitive personal data, and did not include vulnerable populations or interventions, no ethical approval was commissioned.

The first part of the questionnaire asked for the socio-demographic information age, sex, education level, subjective income satisfaction and if someone is an expert in the field of nutrition. Subsequently, the hypothetical choice experiment followed. The products chosen for this choice experiment were apples.

The questionnaire was pre-tested and improved according to the feedback from the pre-test. The survey link was initially distributed via email to colleagues, family members, and friends. These initial contacts were selected with the intention of covering a heterogeneous group, including individuals working in the food and nutrition sector, individuals involved in research, as well as participants without any professional connection to the food domain. In addition, the survey link was shared more broadly via professional platforms such as LinkedIn and other social media channels to reach a wider and more diverse audience. To accurately reflect the demographic structure of the German population, we aimed to recruit participants according to predefined quotas for age and sex, based on the most recent official data from the German Federal Statistical Office (DESTATIS, 2024). Regarding sex distribution, the sample was designed to include 123 males and 127 females, corresponding to approximately 49.3% and 50.7% of the total planned sample size of 250 participants, respectively.

For age distribution, the following target proportions were established:

- <20 years: 18.8%,
- 20–40 years: 24.5%,
- 40–60 years: 27.3%,

- 60–80 years: 22.2%,
- 80 years: 7.2%.

The classification of “experts” and “non-experts” was based on respondents’ self-reported work environment and field of activity. Participants who indicated that they work in a food- or health-related context were grouped as “experts.” This category included individuals with academic or professional backgrounds in food-related disciplines, such as food technologists, food chemists, agricultural scientists, and nutrition scientists. It also comprised researchers working in areas such as food analysis, food quality, or related fields. In general, all participants who are professionally involved in the production, analysis, research, or evaluation of food were classified as experts.

In contrast, participants without any professional or academic connection to the food or health sector were categorized as “non-experts.”

Design of the choice experiment

The questionnaire and choice tasks were implemented using Sawtooth Software’s (Sawtooth Software, Provo, UT, USA) Lighthouse Studio (version 9.5.2), following standard practices for CBC (choice-based conjoint), the recommended parameters for efficient estimation of main and interaction effects (Sawtooth Software, 2017) and adapted from prior literature, including work by Stephan Meyerding. Throughout the survey, consumers repeatedly complete the choice task for a limited number of choice sets (Louviere et al., 2010). We aimed to include a manageable number of attributes (5) with a comparable number of levels per attribute (3–4), ensuring that all levels were logically combinable and that metric differences (where applicable) were evenly spaced. A total of 24 distinct product profiles were used in the study from the full factorial design of 768 combinations. These profiles were randomly assembled into six choice sets per participant, each consisting of three alternatives and an additional “none” option. For all three options, each participant was asked to select their preferred choice of apples or neither by checking the “none” option. The five attributes presented were appearance, promotional claims, cultivation method, regional origin, and price per kilogram, with each attribute having three or four levels. Table 1 shows the attributes as well as levels of each attribute that were used in this choice experiment (here: translated into English). For the attribute “appearance,” three apple varieties that differed in appearance were illustrated using photographs. The apples were sourced from a private garden and were manually sorted based on their external characteristics. The classification aimed to reflect varying degrees of visual imperfection commonly found in real-life contexts. Specifically, the stimuli included: (a) visually “perfect” apples, characterized by a regular shape and absence of visible defects; (b) moderately imperfect apples, showing minor visual deviations such as small brown spots and slight irregularities in shape; and (c) more strongly imperfect apples, with more pronounced visual defects (e.g., larger brown areas and irregular

TABLE 1 Attributes and levels used in the choice experiment.

Attribute	Levels
Appearance	Photo of undamaged apples of uniform size
	Photo of slightly damaged apples
	Photo of more severely damaged apples of varying sizes
Promotional claim	No claim
	“Just as delicious”
	“Simply delicious!”
	“Save me”
Cultivation method	Conventional farming
	Integrated farming
	Organic
	Demeter
Regional origin	Overseas
	Europe
	Germany
	Regional (from the farmer next door)
Price per kilogram	0.99 €, 1.99 €, 2.99 €, 3.99 €

shape), while still being clearly edible and safe for consumption (see Figure 1).

The categorization was based on visual inspection rather than standardized industrial grading criteria, acknowledging that this approach may introduce subjectivity. However, it was chosen to reflect realistic variations in appearance as encountered by consumers outside of retail standardization.

In Figure 2 an example for a combination of apples with different attributes can be seen. The choice experiment was conducted with Sawtooth Software (version 9.5.2).

Statistical analysis

To characterize the study sample, descriptive analyses were conducted. This was followed by the analysis of the discrete choice experiment. To determine consumers' average preferences regarding appearance, claims, cultivation method, regional origin, and price per kilogram, the Hierarchical Bayes model was applied. This model estimates individual utilities using a Monte Carlo Markov Chain algorithm (Sawtooth Software, 2013), allowing for additional insights to be generated. Parameter estimation was conducted using Hierarchical Bayes (HB) procedures implemented in Lighthouse Studio (Sawtooth Software). Estimation relied on Markov Chain Monte Carlo (MCMC) simulation with 20,000 iterations to ensure convergence, while an initial set of draws (10,000) was discarded as burn-in to mitigate the influence of starting values. Default software settings were applied, which have been shown to yield stable results in typical conjoint applications. Convergence diagnostics indicated no irregularities.

Prior to estimation, the experimental design was evaluated using simulation-based efficiency tests. The results showed that the design met commonly accepted thresholds for statistical

efficiency and yielded stable and precise parameter estimates. Minor deviations were within acceptable tolerance levels and did not affect overall design quality. Thus, the experimental setup is considered suitable for robust estimation of preference structures, in line with established best practices in conjoint research (Orme, 2010; Louviere et al., 2000; Meyerding and Schneider, 2026).

Additionally, to account for consumer heterogeneity and identify relevant consumer segments, latent class analysis (LCA) was employed. By analyzing respondents' choices in the discrete choice experiment, latent class choice analysis categorizes consumers into segments with similar preferences. This segmentation is based on individual part-worth utilities derived from the attribute levels used in the experiment (Sawtooth Software, 2021). The identified latent consumer groups were then further characterized based on their socio-demographic characteristics. Data was analyzed by Sawtooth Software (version 9.5.2) and IBM SPSS Statistics (IBM Corp., Armonk, NY, USA).

Results

Study participants

In total, 118 participants completed the choice experiment. Table 2 shows the characteristics of the study sample. The sample consisted of 74.6% female participants. The majority were between 20 and 29 years old (35.9%), while 14.1% were aged 60 and above. Over half of the respondents (55.1%) worked in the food or health sector. Most participants answered that they can live comfortably or can get on with their net household income. Half of the participants had a university degree or Phd (50.8%).

Results of the hierarchical Bayes model

Figure 2 displays the results of the Hierarchical Bayes model (dark blue columns at the left of each attribute), which was applied to assess consumer preferences with regard to apple appearance, promotional claims, cultivation method, regional origin, and price per kilogram. The figure presents the estimated part-worth utilities for each level within the respective attribute categories. Higher part-worth values indicate a greater perceived benefit or preference from the consumer's perspective.

To facilitate comparability across attribute levels, the lowest part-worth utility within each attribute was set to zero.

Results of the latent class analysis

The LCA revealed that the participants could be divided in four segments based on their choices in the choice-experiment. The four segment solution was chosen based on the decrease of the Akaike information criterion (AIC). Smaller values of the AIC are preferred indicating improved model fit. The decrease in the Akaike Information Criterion (AIC) became markedly smaller beyond the four-class solution, indicating diminishing improvements in model fit with additional classes. Further, the researchers carefully



FIGURE 1

Photographs depicting three categories of apple appearance used as an attribute in the survey. The left image shows apples in “perfect” condition, free from any visible defects. The middle image presents apples with minor surface damage. The right image illustrates apples with more pronounced defects, including visible damage and variation in size.

considered the group sizes and the practical implications of the groups. [Figure 3](#) shows the segments including the relative importance of the investigated attributes within each segment. [Figure 4](#) shows the segments including the relative importance of the investigated attributes within each segment.

The first segment, labeled “multi-criteria-focused,” comprises 47.3% of all participants. According to the relative importance values, this group takes all tested attributes into account, except for the claim. They show a clear preference for apples with the most appealing appearance, favor organically grown apples produced regionally, and favor purchasing at the lowest price.

The second segment, referred to as “Sustainability-Focused,” includes 23.5% of all participants. The relative importance values indicate that this group takes price, origin, and production method into account, while claim and appearance play no role in their choices. They show a preference for regionally produced Demeter apples offered at the lowest price.

The third segment, termed “Price-Driven,” comprises 15.8% of all participants. The relative importance values reveal that this group bases its decisions primarily on price, with appearance playing a secondary role. They prefer to purchase visually appealing apples at the lowest possible price.

The fourth segment, labeled “claim/appearance-focused,” represents 13.5% of all participants. The relative importance values show that this group is primarily influenced by appearance and promotional claims, while origin also plays a moderate role. They prefer to purchase the most attractive apples carrying the claim “simply delicious,” especially when these are regionally produced.

Sociodemographic characteristics of the segments

While differences in segment characteristics were not statistically significant, descriptive differences are apparent. The sustainability-focused segment had the highest proportion of female consumers (84.6%). The price driven segment had the

highest proportion of male consumers (42.1%). The mean age was highest in the sustainability-focused segment (44.4 years) whereas the lowest in the price-driven segment (35.1 years). The rationalist segment had the highest proportion of highly educated consumers (80.7%), the price-driven segment had the lowest proportion of highly educated consumers (68.4%).

The segment with the highest proportion of professionals of the food and nutrition sectors was found in the multi-criteria-focused segment (63.2%). The segment with the lowest proportion of professionals was found in the claim/appearance-focused segment (37.5%).

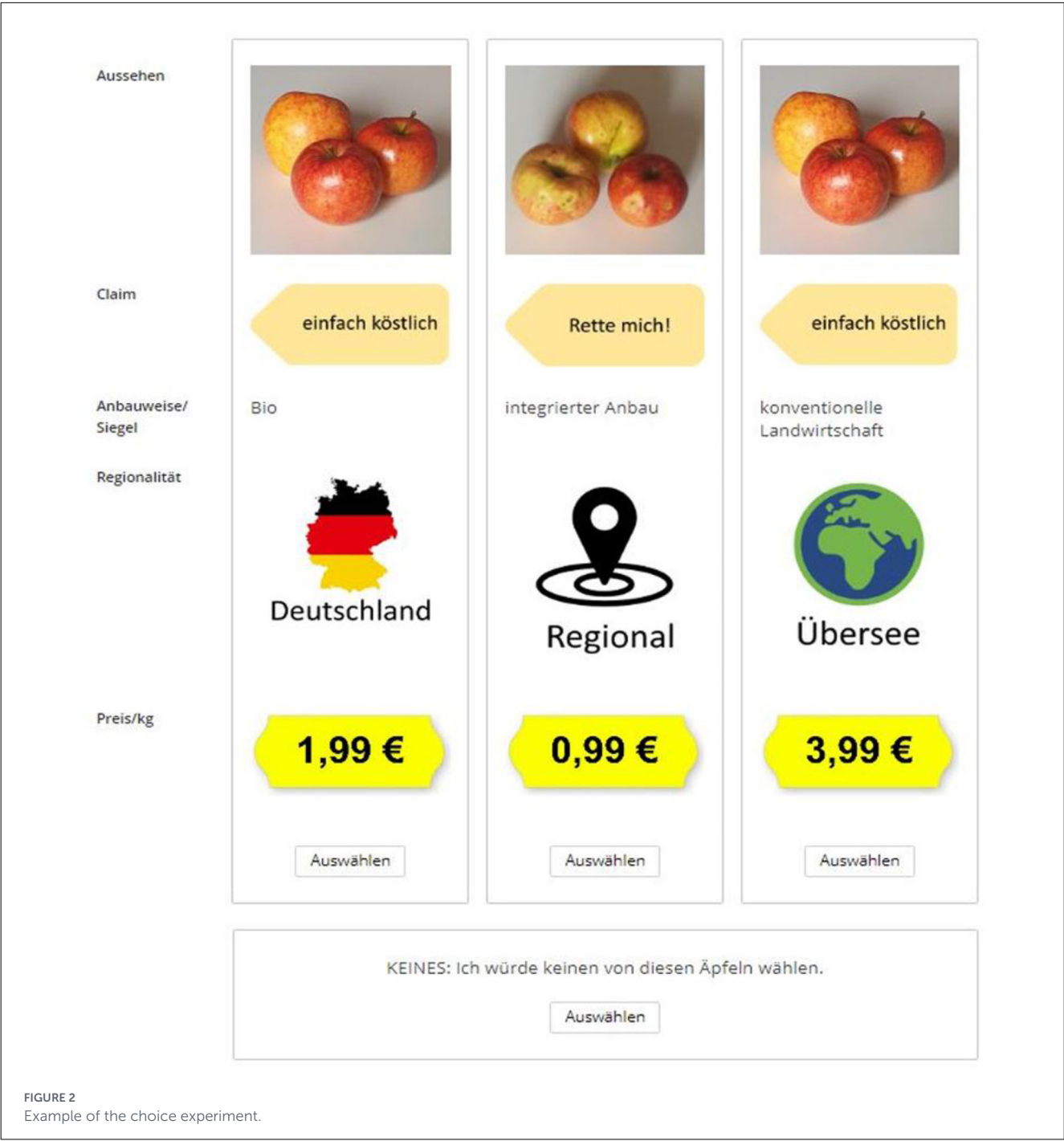
In general, in almost all segments the highest proportion of consumers indicated that they can live comfortably with their net household income (43.9%, 50.0%, and 50.0%, respectively), except in the price-driven segment where the highest proportion of consumers indicated that they can get on with their net household income (47.4%). More detailed descriptions of the characteristics of consumers within each segment can be found in [Table 3](#).

Discussion

Main results and implications for future actions

The aims of this study were (1) to assess the importances of different product attributes for various consumer groups and (2) to identify and profile consumer segments that can be effectively targeted when developing future strategies to reduce food waste in the fruit and vegetable sector. Additionally, to identify implications for future product management strategies aiming at promoting “imperfect” fruits and vegetables.

Consumers that participated in this study could be categorized into four distinct segments based on their purchasing decisions: the rationalists, the sustainability-focused, the price-driven, and the claim/appearance-focused consumers. Each group prioritized different attributes when purchasing apples,



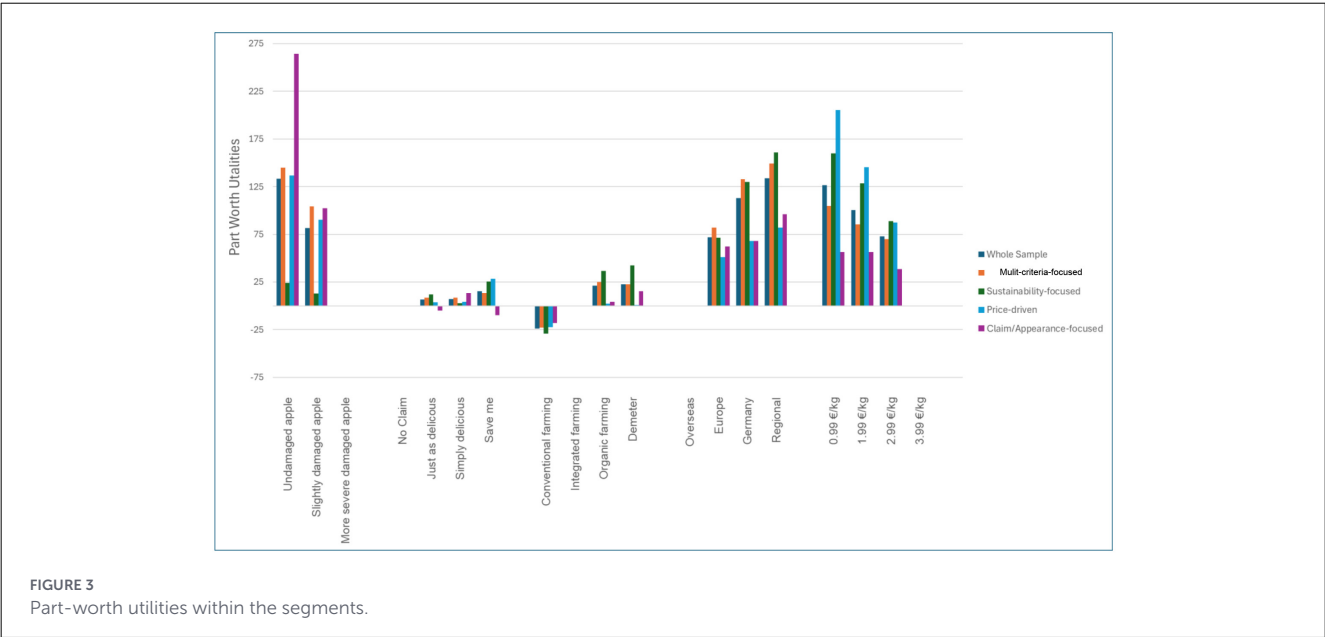
reflecting diverse preferences for both intrinsic and extrinsic product characteristics.

The largest segment consisted of the multi-criteria-focused, comprising nearly half of the respondents. For these consumers, an attractive appearance, regional origin, organic production, and a low price were all simultaneously important. This combination of preferences aligns with the key factors influencing consumer behavior as outlined by Wang et al. (2022) and Meike et al. (2022) and indicates that these consumers tend to take informed decisions after considering almost all available attributes (Meike et al., 2022; Wang et al., 2022). Notably, product-related claims had little to no impact on this group, suggesting a decision-making process that is more information-oriented and less susceptible to marketing messages.

The second segment, the sustainability-focused consumers, considered origin, price, and production method, while largely disregarding both the appearance of the apples and marketing claims. This pattern is partially consistent with the findings of the NABU Survey (2014), which reported that consumers would be willing to purchase visually imperfect produce if the price remained low (NABU—Naturschutzbund, 2014). It can be inferred that these individuals exhibit a heightened environmental awareness and strive to make sustainable consumption choices, consciously renouncing aesthetic appeal and promotional narratives.

TABLE 2 Characteristics of the study sample.

Variable	Description	Frequency (n)	Proportion (%)
Sex	Female	88	74.6
	Male	30	25.4
Age	20–29		
	30–39		
	40–49		
	50–59		
	60–69		
	70+		
Experts in food/health	Yes	65	55.1
	No	53	44.9
Education level	Phd	21	17.8
	University degree	70	33.0
	High school degree	8	6.8
	Apprenticeship	10	4.7
	Secondary school	7	5.9
	Lower secondary school	2	1.7
Income	Live comfortably	53	44.9
	Can get on	49	41.5
	Hard to get on	15	12.7
	Very hard to get on	1	0.8



The third group, the price-driven consumers, focused primarily on price and appearance. For them, apples should be both attractive and inexpensive. Specific marketing standards (SMS) and other EU regulations ensure consistent product quality and appearance, while intense market competition forces retailers to offer appealing products at low prices. However, the environmental cost of such affordability should not be overlooked, as these products are often sourced through long transportation chains and cultivated with

limited regard for organic or sustainable practices. On the other hand, previous research showed that price-driven consumers tend to report lower food waste (Aschemann-Witzel et al., 2018). Finally, the smallest segment comprised the claim and appearance-focused consumers. For this group, visually appealing apples accompanied by enticing sensory claims are of primary importance, whereas price, origin, and production method

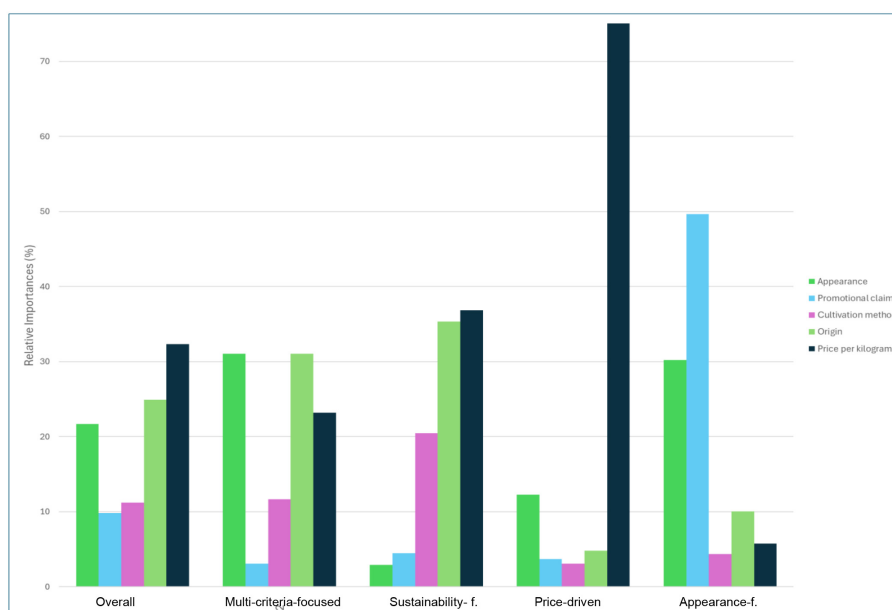


FIGURE 4
Relative importance of attributes within four consumer segments.

TABLE 3 Characteristics of consumers according to the identified segments.

Variable	Multi-criteria-focused (n = 57)	Sustainability-focused (n = 26)	Price-driven (n = 19)	Claim/appearance- focused (n = 16)
Female ^a (%)	78.9	84.6	57.9	62.5
Age [mean in years (SD)] ^b	38.1 (13.2)	44.4 (17.3)	35.1 (15.8)	42.1 (14.4)
Low education level ^c (%)	7.0	7.6	5.3	12.5
Medium education level (%)	12.3	15.4	26.3	12.6
High education level (%)	80.7	76.9	68.4	75.1
Professionals food/health sectors ^d (%)	63.2	46.2	57.9	37.5
Live comfortably ^e (%)	43.9	50.0	36.8	50.0
Can get on (%)	43.9	34.6	47.4	37.5
Hard to get on (%)	10.5	15.4	15.8	12.5
Very hard to get on (%)	1.8	-	-	-

^aFisher's exact test, $p = 0.12$.

^bFisher's exact test, $p = 0.77$.

^cOne-way ANOVA:

$F_{(3,114)} = 1.83$, $p = 0.15$.

^dFisher's exact test, $p = 0.22$.

^eFisher's exact test, $p = 0.97$.

are partially ignored. These consumers appeared particularly responsive to visual and promotional stimuli, making them more susceptible to marketing tactics such as appealing packaging and evocative product descriptions. While this makes them relatively easy to influence through targeted communication strategies, their superficial decision-making may come at the expense of informed and responsible consumption choices. The findings can be further interpreted through the lens of perceived risk and quality signaling theory. Consumers may rely on visual cues such as shape, color, or surface uniformity as heuristic indicators of product safety and sensory quality. In situations characterized by limited information and low involvement, aesthetic perfection may function as a proxy for intrinsic quality attributes. These

higher standards for product appearance can be traced back to cognitive determinants, particularly entrenched decision-making heuristics, such as the implicit belief that “imperfect” equals inferiority, low quality, or even potential health risks. Consumers develop prototypes or mental schemas of how a “normal” product should look. When a product deviates from this prototype and triggers schema incongruity, it may be subconsciously interpreted as less natural or abnormal. This deviation can activate risk perceptions and reduce perceived quality, ultimately leading to product rejection (Giménez et al., 2026; Lagerkvist et al., 2023; Mandler, 1982). Consequently, the rejection of visually imperfect food should not necessarily be interpreted as a lack of knowledge, but rather as the manifestation of deeply embedded cognitive

processes in which visual conformity signals reliability and reduces perceived risk. Embedding this segment of consumers within this theoretical framework provides a more nuanced understanding of the cognitive determinants underlying consumer choice enabling targeting this consumer segment when aiming at enhancing sustainable choices.

The segmentation of consumers into multi-criteria-focused, sustainability-focused, price-driven, and claim/appearance-focused groups highlights the multidimensionality of consumer preferences and the trade-offs individuals are willing—or unwilling—to make in their purchasing decisions. While some consumers aim to balance ethical concerns with practical constraints, others prioritize aesthetics or price with little regard for production method or origin. These findings underscore the importance of targeted marketing and policy interventions that recognize the heterogeneity of consumer values.

However, segmentation based solely on behavioral preferences provides only a partial understanding of the factors shaping consumer decisions. Socio-demographic variables such as sex and income level may further influence how consumers prioritize different product attributes, and could explain underlying motivations for belonging to one segment over another.

In line with the findings of the 2016 survey conducted by the German Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety regarding feelings of guilt associated with food waste, the present study also indicates that female participants tend to exhibit greater environmental awareness [Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (BMUB), 2017]. This is reflected in their higher representation within the sustainability-oriented group compared to male participants. In contrast, men constituted the majority of the price-driven segment, suggesting that price is a particularly salient factor for them when making food purchasing decisions as also described by Aschemann-Witzel et al. (2018).

With regard to age, the sustainability-oriented group displayed the highest mean age, while the price-driven group had the lowest. This pattern may be attributed to younger individuals (e.g., students) with limited disposable income, who may be less willing or able to pay premium prices for sustainably produced food. Older participants, by contrast, are more likely to have the financial means to prioritize sustainability in their purchasing behavior. This interpretation is supported by the high proportion of participants in the price-driven group who reported that their household income is just sufficient to cover their living expenses. These findings underscore that financial constraints play a significant role in shaping food purchasing behavior, particularly among younger consumers. Accordingly, the price-driven group can be characterized as predominantly young and economically constrained.

Beyond sociodemographic variables, this study also examined differences between professionals working in the food sector and lay consumers without a direct connection to the food system. The results revealed that professionals were most strongly represented in the multi-criteria-focused group and least represented in the claim- and appearance-driven group. This suggests that individuals with professional experience in the food sector are more likely to consider multiple objective factors when making purchasing

decisions (e.g., such as price, origin, and production methods) while placing less importance on marketing claims or the visual appeal of the product. These results also indicate that education in the field of food and nutrition can contribute to more multi-criteria-focused and less marketing related decisions when purchasing foods.

Beyond its educational implications, our study also provides several practice-oriented insights. The growing disconnect between farmers and end consumers which is further intensified by the urbanization and industrialization of agriculture, has contributed to declining trust and limited knowledge about food production processes. As only a small proportion of consumers have direct contact with agricultural production, many lack firsthand understanding of how food is grown, processed, and distributed (Colbath and Morrish, 2010; Qi et al., 2022).

This knowledge gap is exacerbated by the increasing complexity of food systems and the abundance of sometimes contradictory information. As a result, consumers may develop skepticism not only toward conventional production methods but also toward organic labels and sustainability claims. Strengthening transparency and direct communication could therefore play a crucial role in rebuilding trust. For example, expanding small-scale retail formats that enable direct interaction with producers, as well as enhancing in-store communication about production methods, quality standards, and sustainability benefits, may help bridge this gap. Clearly communicating how individual purchasing decisions contribute to environmental protection could further enhance acceptance (Chowdhury, 2024; Grewal et al., 2018; Hanss et al., 2016; Lagerkvist et al., 2023; Higgins, 2009; Young et al., 2024).

In addition, deeply rooted consumption habits represent a significant barrier to behavioral change. Consumers often rely on familiar brands and product types, as habitual purchasing reduces cognitive effort and perceived risk. When confronted with information overload or unclear and potentially misleading sustainability claims (e.g., greenwashing), consumers may abandon their sustainable intentions and revert to familiar choices that promise immediate and tangible benefits rather than abstract long-term goals such as environmental protection (Hirsch and Terlau, 2015).

In summary, this study provides valuable insights into the heterogeneity of consumer preferences related to fresh produce, particularly apples, and highlights how sociodemographic and professional factors influence purchasing behavior. By identifying four distinct consumer segments (multi-criteria-focused, sustainability-focused, price-driven, and claim/appearance-focused) it becomes clear that strategies to reduce food waste must be tailored to reflect these varying priorities. While some consumers strive to integrate ethical and environmental concerns into their decisions, others are primarily motivated by price or aesthetics. For multi-criteria oriented consumers, communication should focus on objective product attributes and functional benefits. This includes emphasizing that imperfect produce is equal in quality, taste, and safety compared to visually perfect alternatives, supported by clear and transparent information (e.g., in-store information, comparisons, or data-driven messaging). For sustainability-oriented consumers, marketing should highlight the environmental benefits of purchasing imperfect produce, particularly in terms of reducing food waste. Emotional and

value-based communication, such as storytelling or sustainability labels, can further strengthen engagement. For price-oriented consumers, clear economic incentives are key. This includes visible price discounts, promotional offers, or value-based bundling strategies that make the financial advantage of imperfect produce immediately apparent. For appearance- and claim-oriented consumers, it is important to reframe visual imperfections in a positive and appealing way. Strategies may include emphasizing naturalness, uniqueness, or authenticity, supported by creative branding and attractive product presentation. Overall, the results suggest that a one-size-fits-all strategy is unlikely to be effective. Instead, combining different approaches (e.g., price incentives with sustainability messaging) may further enhance consumer acceptance across segments.

Moreover, demographic variables such as sex, age, and income as well as professional affiliation with the food sector further shape these preferences. These findings underscore the need for differentiated communication and product strategies that address the diverse values and constraints of each segment, particularly in efforts to promote acceptance of “imperfect” fruits and vegetables as part of broader food waste reduction initiatives.

Strengths and limitations

The choice experiment was designed with visual stimuli, which may have contributed to a more realistic presentation of decision-making scenarios and facilitated respondents' ability to imagine actual purchasing situations. The application of advanced statistical analyses allowed for a differentiated evaluation of consumer preferences. In addition, the segmentation of the data enabled a more fine-grained examination of heterogeneous consumer groups. The recruitment and stratification of participants were based on official distribution of the German population, which makes the results more informative. Besides these strengths our study holds some limitations. First, the scenarios represent hypothetical purchase situations, which may not fully reflect actual consumer behavior in real market contexts. Second, the sample size was relatively modest ($n = 118$) and the demographic composition was not fully representative of the German population. In particular, younger individuals (35.9% aged 20–29) and women (74.6%) were overrepresented. We assume that the lower participation rate may be due to several factors. First, the length of the questionnaire may have discouraged potential respondents from completing the survey. Second, limited interest in the topic could have reduced motivation to participate. Third, the distribution channels relied heavily on voluntary participation within personal and extended networks, which may have led to uneven engagement across demographic groups. These factors likely also contributed to the observed deviations from the planned quotas, including the overrepresentation of women and participants aged 20–29. This demographic imbalance may introduce bias into the findings and limits the generalizability of the results. In addition, the limited sample size may have reduced the statistical power to detect significant differences in demographic characteristics between the segments. Consequently, the identified consumer segments should be interpreted as exploratory rather than representative. Future

studies with larger and more demographically balanced samples are needed to confirm and refine the segmentation results. Third, the possibility of self-selection bias cannot be excluded, as individuals with a pre-existing interest in sustainability issues may have been more inclined to participate. This could potentially bias the results in favor of more sustainable choices. Finally, responses may have been subject to social desirability bias, leading some participants to favor the ethically or morally preferable option rather than their true preference.

Implications for future actions

The findings suggest that future interventions should place greater emphasis on targeted communication strategies in order to encourage the acceptance and purchase of “imperfect” fruits among distinct consumer groups. Educational measures appear to play a particularly important role, indicating that campaigns designed to raise awareness and provide information may positively influence consumer attitudes and behaviors. Moreover, both food retailers and direct marketers may contribute to enhancing consumer acceptance by tailoring their product offerings and strengthening communication strategies that highlight the benefits of such products. As mentioned before, consumers can only choose imperfect products if these are actually available. Retailers therefore play a crucial role by including imperfect products in their assortment, placing them visibly in stores, and providing transparent information about their origin and quality through advertising and clear labeling. In summary, future research as well as actions could address questions that convince consumers to consider not only appearance but other attributes of the produce and also to balance and evaluate all attributes such as cultivation method and regional origin together with the claim and price when purchasing as similarly suggested by [De Hooge et al. \(2017\)](#).

Conclusions

In conclusion, the study indicates that consumers are, in principle, willing to purchase imperfect fruits, with specific product attributes exerting a decisive influence on this willingness. The results provide valuable insights that may be translated into practical recommendations for the food retail sector and direct marketing channels, particularly in terms of target group-specific approaches. Nevertheless, the limitations outlined underscore the need for further research with larger, more representative samples and the incorporation of actual purchasing data. Such future studies would not only allow for more robust conclusions but also facilitate meaningful comparisons between theoretical choice models and real-world consumer behavior.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the studies involving humans because participation was totally voluntary, participation could be quit at any time and the data collection was completely anonymous. Therefore, no ethical approval was obtained. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

ZC: Writing – review & editing, Formal analysis, Software, Investigation, Writing – review & editing. LB: Writing – review & editing, Formal analysis, Data curation, Investigation. VW: Investigation, Writing – review & editing, Formal analysis, Data curation. HJ: Methodology, Supervision, Investigation, Data curation, Writing – review & editing, Writing – original draft, Formal analysis.

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