

Optimising honey assurance and traceability systems: Consumer insights and design implications for food integrity across four EU countries

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ABSTRACT

Food fraud in honey poses challenges to consumer trust and market integrity in the European Union. This study examines the role of honey assurance and traceability systems in consumer choice and willingness to pay (WTP) relative to other quality cues, including geographical origin, supply chain characteristics, honey type, and production system attributes. An online survey among 2218 consumers, incorporating a discrete choice experiment, was conducted in Germany, Italy, Portugal, and Slovenia. Consumer preferences and WTP were estimated using Random Parameter Logit (RPL) models. The results show that origin-related attributes are the strongest drivers of consumer utility and WTP, while traceability information, supply chain transparency, and organic production are also valued, albeit to a lesser extent. These findings can inform the design of honey assurance and traceability systems and support efforts to strengthen transparency and consumer confidence in honey markets.

1. Introduction

Food fraud and adulteration are persistent challenges within global food systems, posing significant threats to consumer trust, market integrity, and public health (Kwasi Bannor et al., 2023; Marín et al., 2025; Spink et al., 2016). Food fraud is recognized as a severe public health threat because it can introduce unconventional contaminants and cause serious health risks (Spink et al., 2016). In the European Union (EU), food fraud remains a concern, with 1621 reported incidents between 2020 and 2024 alone (Marín et al., 2025). High-profile cases such as the 2008 melamine adulteration of infant formula in China and the 2013 horse meat scandal in British and Irish markets have heightened public awareness of the issue (Gossner et al., 2009; Walker et al., 2013). Food fraud is also economically damaging, with estimated losses of up to 1.8 billion euros of output and 20,000 jobs per year, particularly in agriculture (Moyer et al., 2017; Rocchi et al., 2020). Within the EU, food fraud is addressed through a combination of horizontal food law, sector-specific legislation, and coordinated enforcement mechanisms. Regulation (EU) 2017/625 on official controls provides the overarching legal framework for preventing, detecting, and responding to fraudulent

practices across the agri-food chain. It defines food fraud as any information indicating the likelihood that consumers may be misled regarding the nature, identity, composition, quantity, durability, or geographical origin of food products (European Parliament and Council, 2017).

To address the challenges posed by food fraud, the adoption of advanced technological solutions is becoming increasingly important, including rapid spectroscopic screening, blockchain-enabled traceability, and digital authentication platforms to enhance detection capabilities and improve transparency across different stages of the supply chain (Wang et al., 2026). Food fraud monitoring is further supported by institutional mechanisms, such as the EU Food Fraud Network and the Rapid Alert System for Food and Feed (RASFF). Such monitoring facilitates information exchange among Member States and the identification of fraudulent practices including adulteration, substitution, and mislabelling (Bouzembrak & Marvin, 2016). Despite these efforts, the lack of a fully harmonized global definition of food fraud still complicates risk assessment and policy evaluation (Marín et al., 2025).

Among food commodities, honey is considered particularly vulnerable to economically motivated adulteration (European Commission,

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2023). Honey is a natural product valued for its nutritional properties and distinctive sensory characteristics, largely influenced by botanical and geographical origin, as well as processing and storage conditions (Balos et al., 2023; European Parliament and Council, 2001). Its market value is closely linked to claims of purity, floral source, and origin, making honey especially susceptible to fraud (Ciursa et al., 2021; Moore et al., 2025). Globally, honey has been identified as the third most frequently adulterated food (Moore et al., 2025; Zhou et al., 2018). Common fraudulent practices include the addition of exogenous sugar syrups, blending high-value mono-floral honeys with lower-quality products, and mislabelling of botanical or geographical origin (Cheng et al., 2024; Wang et al., 2019). Such practices not only distort market competition but may also pose health risks and decrease consumer trust (Ciursa et al., 2021). Furthermore, the European honey supply chain is characterised by a multi-tiered structure involving beekeepers, processors and packers, importers, wholesalers, and retailers, often spanning both domestic production and international sourcing. Relationships among these actors are frequently fragmented and mediated by intermediaries, with limited transparency and information asymmetry across stages (European Union, 2022). This structural complexity increases the vulnerability of the supply chain to adulteration and mislabelling, particularly in cases involving blended or imported honey.

Concerns regarding honey authenticity are particularly pronounced in the EU, where market demand exceeds domestic production, resulting in substantial reliance on imports (European Commission, 2024; Ždiniaková et al., 2023). Empirical evidence from a coordinated investigation conducted by the Joint Research Centre of the European Commission between 2021 and 2022 highlights the scale of the problem. Of 320 honey consignments originating from 20 exporting countries, 147 samples (46%) raised suspicions of non-compliance with the provisions of the EU Honey Directive 2001/110/EC, representing a marked increase compared to a previous control plan conducted between 2015 and 2017, in which 14% of samples were found to be non-compliant (Ždiniaková et al., 2023). These findings reinforced long-standing concerns raised by producers and consumer protection organisations regarding the presence of fraudulent honey on the EU market.

In response, the EU Honey Directive 2001/110/EC was recently amended by Directive (EU) 2024/1438 to introduce stricter and additional control measures aimed at enhancing transparency and consumer protection (European Parliament and Council, 2024). Key provisions include the mandatory and clearly visible indication of countries of origin on honey labels and the introduction of enhanced traceability requirements across the honey supply chain. While such regulatory and analytical measures are essential for mitigating honey fraud, their effectiveness ultimately depends on how consumers perceive, trust, and respond to traceability and authentication mechanisms in the marketplace.

Although a growing body of research has examined consumer perceptions of honey authenticity, food fraud, and traceability, most studies focus on single-country contexts or specific attributes in isolation. Honey authenticity represents a credence attribute because consumers cannot directly verify characteristics such as purity, origin, or production practices even after purchase and consumption. Under such conditions of information asymmetry, consumers rely on external quality signals, including certification, geographical origin indication, and traceability information, to reduce uncertainty and assess product quality (Caswell & Mojduszka, 1996; Darby & Karni, 1973). Therefore, understanding how consumers perceive and value different authenticity signals is essential for evaluating the role of traceability and authentication systems in supporting trust and informed purchasing decisions.

Accordingly, this study examines consumer perspectives on food fraud and traceability across diverse regions of the EU. Specifically, it (1) assesses consumer experience with food fraud, (2) which purchase criteria dominate purchase decisions; (3) compares the relative importance of technological and non-technological solutions, such as

authentication tools, supply chain partnerships, and direct producer–consumer relationships, in building trust in honey authenticity, and (4) estimates willingness to pay for selected honey authenticity attributes using a discrete choice experiment including relation-driven, control-driven, and technology-driven solutions. These findings provide evidence-based insights relevant to consumer-oriented food fraud prevention and ongoing EU regulatory and supply chain governance efforts.

2. Methods

The study employed an online survey including a discrete choice experiment (DCE) to gain **consumer insights on Food Integrity Across Four EU** (see supplement material; questionnaire).

2.1. Questionnaire design, translation, and ethics

The questionnaire was designed to examine consumer perceptions of food traceability and fraud, with the DCE as a central component capturing purchase preferences for honey. The survey began with an introductory section outlining the study purpose, ethical considerations, data protection, and respondents' rights.

For the purpose of this study, the questionnaire included sections on socio-demographic characteristics, honey purchasing behaviour, knowledge and perceptions of food fraud, trust in food system actors, experiences with food fraud, and a honey choice experiment (see Supplementary Material 1).

Respondents were asked to rank the three most important food purchase criteria. The ranked criteria were aggregated (see Section 2.4).

The survey was approved by the Ethics Committee of the Department of Food System Sciences, Research Institute of Organic Agriculture, Switzerland for compliance with the [SRA Research Ethics Guidance \(2021\)](#). All participants were informed about the purpose of the study and provided informed consent before participation. No personal identifying information was collected. Consumer organisations in Italy, Slovenia, Germany, and Portugal translated the questionnaire into local languages and supported the pretesting process. Before starting the data collection, we run several pilot rounds to refine the survey and Discrete Choice Experiment concepts.

2.2. Design of the discrete choice experiment

Discrete Choice Experiments (DCEs) simulate hypothetical purchasing scenarios for consumers (Hair et al., 2003), where participants select one product option from a set of alternatives in each choice set. Grounded in Random Utility Theory, these experiments posit that utility derives not from goods themselves but from their attributes or characteristics (Lancaster, 1966). The core approach involves systematically varying independent attributes across options within choice sets, which affects the selection outcome (Aaker et al., 2001).

McFadden and Train (2000) developed an econometric framework for discrete choice modelling, expressing utility as a linear function of observed alternative attributes. Specifically, an individual will choose alternative from a set of product options only if this option has the highest perceived utility. Honey was chosen as case study product due to its high vulnerability to food fraud (Coral & Mithöfer, 2025). The choice situations were designed to reflect a hypothetical honey purchase scenario, allowing respondents to evaluate and trade off multiple product attributes when making purchasing decisions. The attributes selected for the DCE are presented in [Table 1](#) and reflect key information cues relevant to consumer trust, including geographical origin, traceability and authentication tools, hereunder focussing on recently developed technical solutions for authentication and traceability:

1. **Tool for testing for authenticity of the geographical origin** of the honey as fraud prevention with the spectroscopy — hyper spectral

Table 1
Attributes and levels included in the discrete choice experiment.

Attribute	Level
Geographical origin	1. Produced outside the EU 2. Produced in the EU 3. Produced in the own country
Traceability and tool to test the authenticity of honey in terms of geographical origin and adulteration	1. No specification for traceability 2. Tool for testing for authenticity of the geographical origin 3. Tool for testing for authenticity of the honey (not being adulterated with sugar) 4. Tool for testing for both authenticity of geographical origin and the product not being adulterated with sugar
Specific supply chains	1. No specification about supply chain 2. Honey from strong supply chain partnership with transparency about the single actors along the supply chain involving producers, distributors and marketers. 3. Honey from short supply chain: Direct sale from producer to consumer
Type of honey	1. Honey from unspecified type/mix 2. Honey from agricultural crops 3. Honey from trees 4. Honey from herbs
Production system	1. Honey from conventional production 2. Honey from organic production
Product price for 500/900 g of honey	1. Average honey consumer price in respective case study country 2. 50 percent higher than average consumer price in the respective study country 3. 100 percent higher than average consumer price 3. 150 percent higher than average consumer price in the respective study country

imaging-based sensor method. Consumers can access information of the testing results via QR code.

2. **Tool for testing for authenticity of the honey (not being adulterated with sugar)** with the portable NIR-HIS based sensor method. Consumers can access information of the test results via QR code.

Additionally, supply chain characteristics were incorporated into the DCE as non-technology-based alternatives that may influence consumer trust in product authenticity. The production system—contrasting organic versus non-organic approaches—was another attribute, as trust in authenticity may vary across these systems (De Canio & Martinelli, 2021). Botanical origin (herbs, crops, fruit trees, or unspecified/mixed) was included, given potential differences in consumer preferences for honey types. Finally, price was added to estimate the monetary constraint associated with each attribute and level.

The average price was initially selected, based on observations during price inventories conducted in each study country. Four different price levels with 50 % increments, namely 50%, 100%, and 150% of the average price of honey were selected to be included in the experiment, capturing the high price variation of the product. Prior to the choice tasks, all attributes and levels were briefly explained to respondents (see Supplementary Material 1). To reduce hypothetical bias, participants were explicitly instructed to consider their actual budget constraints when making their choices (Lusk & Schroeder, 2004; Tonsor & Shupp, 2011).

The choice experiment employed an unlabelled design, omitting option-specific details, such as brand names. Instead, the design included three options presented as “Option 1,” “Option 2,” and “Option 3, while option 3 was a “no buy” option. The inclusion of a no-buy option reflects realistic market conditions and avoids forcing respondents to make a purchase decision, thereby improving external validity and

consistency with consumer choice theory (Dhar & Simonson, 2003; Louviere & Lancsar, 2009; Risius et al., 2017; Schulze et al., 2021). the attributes included in the choice experiment were distributed across “Option 1” and “Option 2” based on a D-efficient design. Unlike orthogonal designs, which reduce attribute correlations, D-efficient designs minimize standard errors in parameter estimates. The design was created using Ngene 1.4 software (ChoiceMetrics, 2024). Furthermore, the DCE followed a blocked experimental design with two blocks to reduce the choice scenarios consumers were faced and by thus reduce respondents' cognitive burden. Respondents were randomly assigned to one of two blocks, each containing six choice sets, for a total of twelve choice sets overall. Within each block, the order of the choice scenarios was randomised across respondents.

2.3. Data collection

Data were collected through an online survey administered by the market research agency Bilendi over a two-week period in August 2024 in Slovenia (SI), Portugal (PT), Italy (IT) and Germany (DE), which were the participating countries in the research project from which the data were collected. Although the selection of countries was determined by the project consortium, the four countries represent diverse European contexts with respect to honey market characteristics, beekeeping traditions, and consumer behaviour. Germany and Italy are among the largest honey markets in Europe, while Slovenia has a long-standing beekeeping tradition and one of the highest per-capita honey consumption rates in Europe. Portugal represents a smaller southern European market with an established beekeeping sector. This diversity provides a suitable basis for comparing consumer preferences and willingness to pay across different European market contexts. Quota sampling was applied to obtain samples representative of each country's population in terms of age, gender, and region. Sampling was stratified by NUTS 3 regions in Germany and Italy and by NUTS 2 regions in Slovenia and Portugal.

Respondents were aged 18–74 years and distributed across five age groups as seen in Table 2. Approximately 500 respondents per country participated. The survey could be completed on a computer, tablet, or smartphone. Most questions were displayed in random order, except where a fixed order was necessary (e.g. age, income, and education). The average completion time was approximately 20 min.

2.4. Data analysis

Prior to analysis, the dataset was cleaned by removing incomplete responses and observations with unrealistically short completion times. A minimum display time was imposed on the introductory screen to ensure respondents were exposed to the study information. The survey data was analysed using IBM SPSS Statistics (Version 24) (IBM Corp, 2020). Descriptive statistics, means and standard deviations were calculated. The relative importance of each purchasing attributes (Table 6) was quantified using a weighted ranking score per attribute per country. Responses were aggregated using a Borda (Hristov et al., 2023) count-inspired weighting scheme, assigning weights of 3, 2, and 1 to first, second, and third-place rankings, respectively:

$$\text{Score} = (\% \text{ranked1st} \times 3) + (\% \text{ranked2nd} \times 2) + (\% \text{ranked3rd} \times 1)$$

This approach reflects both the frequency and intensity of preference across respondents. Deviations were calculated by subtracting the cross-country mean for each attribute from the corresponding country score (Deviation = Country Score – Cross-country Mean), where positive values indicate above-average importance and negative values indicate below-average importance in a given country.

Choice data were analysed using NLOGIT Version 6 (Greene, 2016). We estimated Random Parameter Logit (RPL) models, which allow for preference heterogeneity across respondents and make efficient use of repeated choice observations (McFadden & Train, 2000; Train, 2009),

Table 2
Sample description of single study countries (n = 2218).

Sample size n	Slovenia 549	Portugal 558	Italy 554	Germany 557
Gender				
Female	48.6%	51.8%	49.8%	50.3%
Male	51.4%	48.2%	49.8%	49.6%
Other	0.0%	0.0%	0.4%	0.2%
Age group				
18–29	16.2%	17.6%	16.6%	18.0%
30–39	17.9%	16.1%	15.3%	18.3%
40–49	20.6%	20.4%	19.7%	16.7%
50–59	19.7%	19.7%	22.6%	21.9%
60 >	25.7%	26.2%	25.8%	25.1%
Household size	2.88	2.71	2.86	2.36
Number of children	1.74	1.55	1.57	1.63
Level of Education				
No formal education	0.5%	0.2%	0.0%	5.6%
Primary school	4.2%	4.3%	2.3%	21.4%
High School	58.8%	44.6%	60.8%	42.7%
University/tertiary education	36.4%	50.9%	36.8%	30.3%
Place of residence				
Urban area	44.8%	54.8%	54.2%	43.4%
Suburban area	23.7%	25.8%	29.6%	24.4%
Rural area	31.5%	19.4%	16.2%	32.1%
Municipality size				
Less than 9999 inhabitants	34.6%	13.6%	20.0%	26.2%
10,000 to 49,999 inhabitants	32.6%	35.1%	30.1%	27.6%
50,000 to 99,999 inhabitants	12.8%	21.7%	18.8%	10.4%
100,000 to 249,999 inhabitants	9.7%	16.3%	10.1%	12.0%
250,000 to 499,999 inhabitants	8.4%	6.1%	4.7%	5.4%
500,000 inhabitants or more	2.0%	7.2%	16.2%	18.3%
Employment status				
Employed	60.3%	70.1%	62.6%	69.1%
Homemaker	1.8%	1.3%	9.2%	4.1%
Unemployed	5.6%	5.0%	6.9%	4.1%
Retired	24.2%	17.7%	15.3%	11.7%
Student	6.9%	3.9%	5.2%	4.8%
Other	1.1%	2.0%	0.7%	6.1%
Gross monthly household income				
1499 € or less	28.2%	32.4%	18.4%	14.0%
1500 € - 2999 €	38.4%	43.4%	47.7%	27.8%
3000 € - 5999 €	25.3%	18.6%	24.0%	43.8%
6000 € - 8999 €	4.4%	2.0%	5.4%	9.7%
9000 € - 11,999 €	1.8%	1.3%	1.4%	2.7%
12,000 € and above	1.8%	2.3%	3.1%	2.0%

while separate RPL models were estimated for the four case study countries based on actual market prices. Model fit was assessed using the log likelihood, adjusted pseudo-R², and the Akaike Information Criterion (AIC), with better fit indicated by higher log likelihood and adjusted pseudo-R², and lower AIC. Willingness-to-pay (WTP) measures were derived from the estimated Random Parameter Logit model coefficients by expressing the marginal utility of each non-price attribute relative to the marginal utility of price. Specifically, WTP for a given attribute was calculated as the negative ratio of the attribute's estimated coefficient to the price coefficient, representing the marginal rate of substitution between the attribute and price (Train, 2009). This approach allows the transformation of utility-based preference estimates into monetary values that indicate the additional amount consumers are willing to pay for a change in a given attribute, holding utility constant.

3. Results

3.1. Sample description

The final analytical sample comprised 2218 respondents from four European countries: Slovenia (n = 549), Portugal (n = 558), Italy (n = 554), and Germany (n = 557). The choice experiment was administered only to respondents who reported consuming honey. Participants who indicated that they did not consume honey were not presented with the choice experiment, as the hypothetical purchasing scenarios were not

relevant to them. These respondents completed the remaining sections of the questionnaire. Consequently, the sample size for the choice experiment analyses is smaller (n = 1976) than the total survey sample (n = 2218).

No major deviations from national population characteristics were observed. The sample shows an equal share of males and females, as targeted by quota sampling (see Table 1). The study participants are more educated than general populations in Germany (vs. 18.5% with bachelor's degree and higher; Statistisches Bundesamt, 2024) and Italy (vs. 27.6%; Eurostat, 2024), but less so in Portugal (vs. 55% upper secondary 25–64 years; OECD, 2024). The Slovenian sample shows larger households (2.88 vs. 2.41 members) and more children under 18 (1.74 vs. 1.10–1.56 avg.) than population averages (Razpotnik & Žnidaršič, 2021). Furthermore, the Slovenian sample has fewer pensioners (vs. 29%; Razpotnik and Žnidaršič, 2021), lower rural share, and slightly higher employment than national rates (Zaletelj et al., 2021). Table 2 presents the socio-demographic characteristics of the sample.

3.2. Consumers' preferences and willingness to pay for honey authenticity and traceability

Table 3 presents the estimated utility coefficients and standard deviations from the DCE based on Random Parameter Logit Models, estimated country wise.

The Model fit, expressed by the McFaddens R², ranging from 0.18 in Slovenia to 0.34 in Germany indicates a relatively high model fit (Hemmert et al., 2018). The models showed an improvement in log likelihood relative to the baseline specification.

The coefficients indicate the direction and relative strength of consumer preferences for the included honey attributes and should be interpreted as measures of utility rather than monetary values. While the estimates form the basis for subsequent willingness-to-pay calculations, interpretation at this stage focuses on the relative importance of attributes within each country. Direct comparisons of coefficient magnitudes across countries are limited due to differences in market conditions and socio-demographic characteristics, therefore, the results are primarily discussed in terms of preference patterns rather than absolute effect sizes.

As a general result, the Italian model exhibits substantially larger coefficient estimates than the other country models. This pattern reflects differences in the scale of the estimated utility rather than necessarily stronger preferences for all attributes. Since each country model is estimated separately, coefficient magnitudes depend on the variance of the unobserved component of utility (the scale parameter). Consequently, coefficients should be interpreted primarily in terms of their sign and relative importance within each country rather than compared directly across countries.

Overall, the results indicate that credence attributes play a dominant role in consumer preferences across all countries. Credence attributes refer to product characteristics that consumers cannot readily verify through direct use or consumption (Fernqvist & Ekelund, 2014). As a result, these attributes are typically communicated through labels, certifications, or other assurance schemes. In the context of food products, credence attributes include aspects such as food safety, animal welfare, environmental sustainability, country of origin, health-related claims, and organic production practices. Attributes related to geographical origin, particularly EU and national origin, exhibit positive and statistically significant effects in all models, highlighting its importance as a quality cue in honey choice (refer to Table 3).

Similarly, traceability through geographical origin testing consistently increases utility, whereas testing for adulteration alone shows weaker and more heterogeneous effects. This suggests that consumers may associate credence attributes more strongly with quality and authenticity than with technical fraud detection measures.

Attributes related to the supply chain, such as strong supply chain partnerships and direct sales, also contribute positively to consumer

Table 3

Random Parameter Logit Models of consumer honey choices in case study countries based on real market price levels.

Parameters		SI	PT	IT	DE
Geographical origin	Produced in EU	0.39***	0.47***	6.27***	0.33***
	Produced in Country	0.33***	0.39***	4.13***	0.82***
Traceability	Testing geographical origin	0.42***	0.32***	0.68***	0.45***
	Testing for adulteration	−0.08	−0.14**	−0.43	0.14
Supply chain	Testing geographical origin and adulteration	−0.05	−0.02	−0.86	0.48***
	Strong supply chain partnership	0.36***	0.40***	1.56***	0.32***
Honey type	Direct sales	0.39***	0.41***	2.12***	0.09
	From crops	0.04	0.19***	3.46***	0.66***
	From herbs	−0.28***	0.09	1.30***	0.14
	From trees	0.25***	0.28***	−3.10**	−0.20**
Production system	Organic	0.30***	0.26***	1.44***	0.38***
Price level	-	−0.03***	−0.03**	−1.00***	−0.15***
Standard deviations					
Geographical origin	Produced in EU	0.62***	0.18	0.23	0.23
	Produced in Country	0.76***	0.79***	0.44**	0.52**
Traceability	Testing geographical origin	0.33	0.26	0.60***	0.71***
	Testing for adulteration	0.45**	0.74***	2.08***	1.00***
Supply chain	Testing geographical origin and adulteration	0.32*	0.63***	0.44*	0.53*
	Strong supply chain partnership	0.67***	0.08	0.78***	0.42
Honey type	Direct sales	0.36***	0.03	0.14	0.13
	From crops	0.60***	0.86***	0.25	1.63***
	From herbs	1.46***	1.06***	1.83***	0.86***
	From trees	0.27**	0.027	0.01	0.44***
Production system	Organic	1.55***	1.23***	2.66***	2.15***
Price level	-	0.12***	0.24***	0.19***	0.40***
N		529	511	507	429
Observations		3174	3066	3042	2952
Fit statistics	McFadden R2	0.18	0.20	0.26	0.34
	Log likelihood	−2892.90	−2708.02	−2513.10	−2313.46
	AIC	5784.6	5408.4	5015.5	4317.9
	AIC/N	1.827	1.764	1.649	1.463

Significance levels: $p < 0.001$ (***), $p < 0.01$ (**), $p < 0.05$ (*).

utility in most countries, underlining the role of trust and perceived transparency in honey markets. Preferences for honey type vary considerably across countries, indicating pronounced taste diversity and culturally specific consumption patterns. In contrast, organic production is positively valued across all markets, confirming its function as a widely recognised quality signal.

Furthermore, the second part of Table 3 includes the standard deviations (SD) of the parameters. The presence of statistically significant standard deviations for most parameters in most countries points to substantial preference variation within all study countries, suggesting that consumer preferences differ in how they value origin, traceability, and production characteristics. More specifically, the models estimated for Italy and Germany tend to have more and larger significant SDs on credence and quality signals (testing, organic, honey type) than the Slovenian and Portuguese models, indicating more polarized consumer segments in these markets. In addition, the standard deviations show that origin and organic attributes are heterogeneous in every country, while the intensity and heterogeneity differs between countries: the Slovenian and Portuguese models are characterised by SD high values for origin (especially “Produced in Country”), In Italy and Germany, the SD values are high for organic and authenticity testing, and all four for “herbs” honey, with Germany additionally showing striking heterogeneity in honey type and price sensitivity. The product price parameter has small but significant SDs in all countries (0.12–0.40***), so price sensitivity is heterogeneous but less variable than preferences for organic or honey type; Germany shows the largest SD (0.40***) related to the price parameter.

The WTP values are reported in Table 3. As these values are based on a hypothetical honey choice experiment rather than observed market behaviour, caution is required when transferring the absolute WTP estimates to real market conditions. Nevertheless, the relative magnitude of the WTP values provides useful insights into how consumers prioritise different honey attributes and indicates which characteristics are more likely to drive a price premium in a real purchasing context. Cross-

country comparisons of absolute WTP values are inherently limited due to substantial differences in national food environments and socio-demographic characteristics, particularly household income levels. Therefore, the interpretation focuses on the relative importance of attributes within each country, rather than on direct numerical comparisons of WTP estimates across countries. The results furthermore indicate that, within each country, the estimated willingness to pay for honey produced in the EU or in the consumer’s own country is consistently higher than the willingness to pay associated with honey type attributes and higher than that associated with organic production (see Table 4). This finding highlights the important role of source authenticity-related attributes relative to production and product characteristics. Across all countries, consumers show a positive willingness to pay for honey tested for the authenticity of its geographical origin.

In contrast, willingness to pay for testing for adulteration alone, as well as for combined testing of origin and adulteration, is generally weak or statistically insignificant in most study countries. An exception is observed in Germany, where consumers exhibit a positive willingness to pay for honey tested for both origin and adulteration. However, the results suggest that even in this case, consumers place greater value on origin verification than on adulteration testing within the combined testing framework.

Supply chain-related attributes, such as strong supply chain partnerships and direct sales, are associated with positive willingness-to-pay estimates in most countries, indicating that consumers value trust-enhancing and transparency-related marketing arrangements. Preferences for honey type vary across countries, reflecting differences in taste and consumption patterns, with some honey types attracting positive willingness-to-pay estimates while others are weakly valued or negatively perceived. Finally, organic production is associated with a positive willingness to pay in all countries, although its relative importance remains lower than that of origin-related attributes.

Table 4

Willingness to pay values for honey attributes based in real market price levels in Euros (values expressed in monetary units per stated package size).

Honey Attribute	Attribute level	SI 900 g of honey	PT 500 g of honey	IT 500 g of honey	DE 500 g of honey
Geographical origin	Produced in EU	13.00	15.67	6.27	2.20
	Produced in Country	11.00	13.00	4.13	5.47
Traceability	Testing geographical origin	14.00	10.67	0.68	3.00
	Testing for adulteration	ns	-4.67	ns	ns
	Testing geographical origin and adulteration	ns	ns	ns	3.20
Supply chain	Strong supply-chain partnership	12.00	13.33	1.56	ns
	Direct sales	13.00	13.67	2.12	ns
Honey type	From crops	ns	6.33	3.46	4.40
	From herbs	-9.33	3.00	1.30	ns
	From trees	8.33	9.33	-3.10	-1.33
Production system	Organic	10.00	8.67	1.44	2.53

ns = not significant.

3.3. Consumers' experiences regarding food fraud

This section presents descriptive results on respondents' personal experience with food fraud and the perceived relevance of food safety and traceability as purchasing criteria collected within the survey. Overall, 24.3% of respondents reported having personally encountered a fraudulent food product at some point. The highest share of consumers reporting such experience is observed in Slovenia (33.0%), while the lowest share is reported in Italy (19.9%) as seen in Fig. 1.

Awareness of food fraud occurring at the national level is highest among Italian respondents, with 80.3% indicating that they have heard of food fraud in their country, followed by respondents in Portugal (60.0%) as visualized in Fig. 2. While Slovenian and German respondents report lower levels of awareness, a majority in both countries still acknowledge the occurrence of food fraud. A notable proportion of respondents, particularly in Germany (12.6%), indicated that they did not know whether food fraud was occurring in their country.

Consumers' reactions after experiencing food fraud differ across countries, however, in all cases, the most common response is to discard the product presented in Table 5. Overall, 30.2% of respondents who reported having experienced food fraud indicated that they threw the

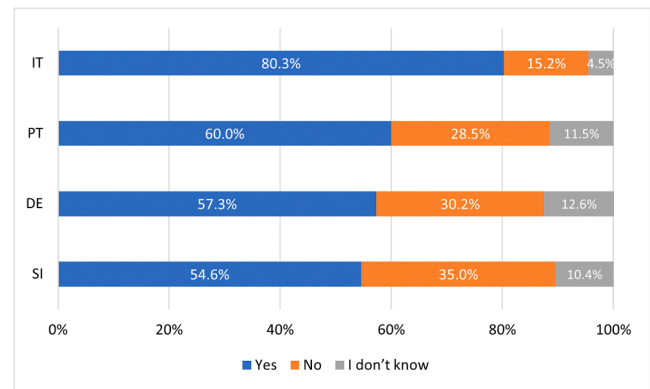


Fig. 2. Share of consumers reporting having heard of food fraud happening, by country.

Table 5

Respondents' reaction after experiencing food fraud.

	SI	PT	IT	DE	Total
I just threw it away	30.9%	32.2%	31.8%	26.0%	30.2%
I returned it to the shop	27.1%	23.1%	28.2%	20.5%	24.9%
I asked for refunding	17.7%	15.7%	17.3%	18.1%	17.3%
I kept the food and ate it anyway	10.5%	10.7%	13.6%	22.0%	13.9%
I looked for additional information before making a decision	11.0%	13.2%	13.6%	14.2%	12.8%
I contacted the brand	9.9%	5.8%	22.7%	10.2%	11.7%
I contacted the authorities	13.8%	6.6%	6.4%	9.4%	9.6%
Not sure / it depends	5.0%	10.7%	4.5%	11.8%	7.8%
Other:	3.3%	9.9%	4.5%	11.8%	7.1%

food away, with Portugal standing out with a slightly higher share (approximately two percentage points above the average). The second most common reaction, reported by around one quarter of respondents, is returning the product to the shop. Germany represents an exception, where a relatively higher share of consumers reported keeping the product and consuming it despite suspecting fraud. The least frequently reported reactions across countries involve contacting authorities in Italy and Germany and contacting the brand or producer in Slovenia and Portugal.

Based on the calculated weight ranking mean scores from the ranking data of the evaluated attributes, cost/price clearly emerges as the most influential factor in food purchasing decisions across all countries, with the highest cross-country mean score (191.5), as presented in Table 6. This dominance is particularly pronounced in Slovenia and Portugal, where price scores are above the cross-country average, confirming its central role in consumer decision-making. Taste ranks as the second most important attribute overall (mean score: 106.2), with especially high relevance in Germany, where its score substantially exceeds the cross-country mean. Freshness follows closely (mean score: 95.0), standing out as the leading non-price attribute in Portugal and showing relatively strong importance in Germany as well.

Attributes related to nutritional quality occupy a middle position in the overall evaluation. Nutrient content achieves a moderate mean score (69.1), with comparatively higher importance attributed by Portuguese and Italian consumers. Similarly, food origin (mean score: 49.9) and food safety (mean score: 44.7) display notable cross-country variation. Italian respondents place greater emphasis on origin, while food safety is valued more strongly in Slovenia and Portugal, but considerably less in Germany.

In contrast, ethics and beliefs, environmental and climate impact, and traceability consistently receive the lowest mean scores across all countries. Ethics and beliefs show slightly higher relevance in Germany and Italy yet remain of limited importance overall. Environmental and

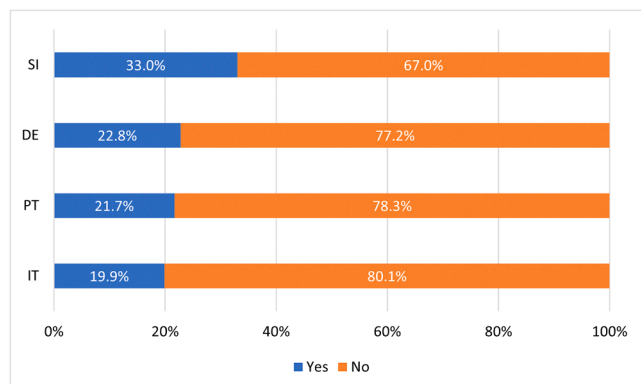


Fig. 1. Share of consumers reporting having encountered a fraudulent product, by country.

Table 6

Weighted ranking score of food purchasing attributes, by country, with deviations from the cross-country mean.

Attributes	Weighted Ranking Score				
	SI	PT	IT	DE	Mean
Cost /price	199,6	195,2	181,7	189,3	191,5
Taste	110,9	89,8	87,8	136,1	106,2
Freshness	79,0	123,5	85,1	92,2	95,0
Nutrient content	63,7	75,4	72,0	65,4	69,1
Origin	55,7	39,7	67,7	36,3	49,9
Food safety	54,6	53,6	42,8	27,8	44,7
Ethics and beliefs	20,4	10,9	32,1	36,0	24,9
Impact on the environment and climate	11,6	7,7	16,1	14,2	12,4
Traceability	12,0	4,5	14,3	2,7	8,4
Deviation from mean					
Deviation					
Cost /price	8,1	3,8	−9,8	−2,1	
Taste	4,8	−16,4	−18,4	30,0	
Freshness	−16,0	28,6	−9,9	−2,8	
Nutrient content	−5,4	6,3	2,9	−3,7	
Origin	5,8	−10,2	17,9	−13,6	
Food safety	9,9	8,9	−1,9	−16,9	
Ethics and beliefs	−4,5	−14,0	7,3	11,2	
Impact on the environment and climate	−0,8	−4,7	3,7	1,8	
Traceability	3,6	−3,9	5,9	−5,7	

climate considerations (mean score: 12.4) and traceability (mean score: 8.4) are the least influential attributes in consumers' food purchasing decisions, particularly in Portugal and Germany, indicating that these aspects play a relatively minor role compared with economic and sensory factors.

4. Discussion

This study provides cross-country evidence to inform the design of honey traceability and authentication systems that address consumer preferences while reducing food fraud vulnerability across the supply chain. Ranking results indicate that cost, freshness, and taste dominate general food purchasing decisions, whereas traceability, food safety, and environmental considerations receive comparatively lower priority. Although food fraud awareness is widespread, direct experience remains limited. However, the discrete choice experiment demonstrates that fraud-related attributes — particularly verified origin and selected traceability cues — generate positive willingness-to-pay (WTP) when consumers evaluate honey products. This reveals a structural distinction between general purchasing heuristics and attribute valuation under product-specific choice conditions. Significant preference heterogeneity further suggests the existence of distinct consumer sensitivities to origin and traceability signals. By studying attitudinal rankings, awareness indicators, and WTP estimates, this study contributes to food fraud research by demonstrating that trust-related attributes operate conditionally rather than as dominant baseline decision criteria.

The strong valuation of geographical origin observed in the choice experiment aligns with existing literature highlighting the importance of provenance information in consumer food choices, with many consumers expressing preferences for domestic or locally sourced products (Thøgersen, 2023; Traoré et al., 2023). One explanation identified in this literature is that consumers often perceive supporting local or national producers as a personal or social responsibility. Furthermore, recent honey-specific studies conducted across several European countries similarly report origin-related attributes as important factors influencing consumers' honey purchasing decisions. Recent studies from Italy, Spain, and Slovakia indicate that consumers consider provenance, quality labels, and product characteristics when evaluating honey products (Ballco et al., 2022; Oravec et al., 2020; Pocol et al., 2022; Šedík et al., 2023; Sparacino et al., 2022). From a theoretical

perspective, these findings are consistent with signalling theory and information asymmetry frameworks, according to which origin labels serve as observable signals that reduce uncertainty in markets for credence goods (Schrobbach et al., 2023; Spence, 2002).

Although traceability and fraud-related attributes do not feature prominently in the ranking of general food purchasing criteria, their positive willingness-to-pay estimates in the choice experiment are consistent with earlier research indicating that consumers value informational cues such as traceability and quality assurance, particularly in contexts where trust in food safety systems plays a role. Recent research continues to identify food safety as a major credence attribute influencing consumer decision-making across markets. Consumers often cannot directly verify safety, authenticity, or production practices at the point of purchase and therefore rely on external cues such as certification, traceability information, country-of-origin labels, and other assurance claims to reduce uncertainty (Schrobbach et al., 2023; Wu et al., 2021). In the UK and other developed food markets, traceability and origin-based labelling remain important mechanisms for rebuilding consumer confidence following food safety and food fraud events. More broadly, studies suggest that labels communicating provenance, quality assurance, and supply-chain transparency function as trust-building signals, particularly where consumers perceive risks related to authenticity, contamination, or information asymmetry (Conroy & Lang, 2021; Contini et al., 2023; Ge, 2022).

The relatively low ranking of traceability and fraud-related attributes despite comparatively high levels of food fraud awareness, particularly in Italy, may reflect differences in consumers' familiarity with and exposure to specific types of information. Origin-related labels and quality certification schemes are widely used in European food markets, making them familiar and easily interpretable quality cues (De Canio & Martinelli, 2021; Fekete et al., 2025). In contrast, fraud verification measures are less visible to consumers, are primarily implemented through regulatory controls rather than consumer-facing information, and may therefore be less well understood. As honey is a credence good, consumers cannot directly verify authenticity or purity even after consumption and consequently rely more heavily on observable extrinsic cues, such as origin and certification, to reduce uncertainty (Schrobbach et al., 2023). This may explain why traceability and verified origin receive limited attention in general purchasing criteria but generate positive willingness-to-pay when explicitly presented as product attributes.

In contrast, testing for adulteration alone generated weak, non-significant, or even negative utility estimates in several countries. This suggests that consumers distinguish between information confirming product authenticity and messages referring explicitly to fraud detection. Explicit references to adulteration may evoke concerns about food fraud, reducing product attractiveness rather than increasing confidence in its authenticity. These findings indicate that the effectiveness of fraud-related communication depends not only on the information provided but also on how that information is framed and understood by consumers.

Beyond consumer acceptance, the practical value of authentication and traceability systems depends on their analytical and operational feasibility. Recent developments in food authenticity assessment, including sensor-based approaches, spectroscopic techniques, and digital traceability tools, indicate increasing potential for rapid verification of product characteristics and origin. However, the implementation of such systems requires consideration of measurable performance parameters, including detection capability, sensitivity to adulteration, robustness across different honey types and geographic origins, analysis time, operational costs, and compatibility with existing quality control procedures. While consumers in this study valued verified origin and authenticity-related attributes, the effectiveness of these signals depends on reliable underlying verification mechanisms that can generate trustworthy information throughout the supply chain. Therefore, authentication technologies should be evaluated not only based on their

technical accuracy but also on their scalability, affordability, and feasibility for routine use by producers, processors, and control authorities.

From a governance perspective, increasing transparency regarding authenticity verification mechanisms may strengthen consumer trust (Kasza et al., 2024; Wu et al., 2021), and particularly in import-dependent markets where fraud risks are documented. However, consumer-facing communication strategies should complement, not replace, official fraud detection and enforcement systems. The results suggest that while consumers are not willing to assume primary responsibility for fraud control, they do attach economic value to credible authenticity signals when these are made explicit and trustworthy.

From a supply chain perspective, traceability and transparency mechanisms can improve accountability and consumer trust by linking product flows with verified information flows (Coral & Mithöfer, 2025; Manara et al., 2025). In honey supply chains, such systems can record origin and verification information and communicate selected authenticated details to consumers. Our discrete choice experiment similarly shows positive preferences and willingness to pay for strong supply chain relationships and direct sales, although these measures do not by themselves demonstrate reduced fraud occurrence.

Previous research showed that in cases, where consumers do not have information about honey fraud, they do not value US honey any more than imported honey, though they are willing to pay a premium for both organic and local honeys (Gustafson et al., 2024). The WTP results in this study show that organic honey consistently has positive value across all four countries, confirming the findings of Gustafson et al. (2024), with highest relative (within-country) valuations in Portugal and Slovenia. This indicates that organic certification functions as a credible extrinsic cue and partially substituting for direct quality assessment and authenticity cue in a market characterised by information asymmetry. While WTP for organic is generally lower than for geographical origin or selected traceability attributes, it complements these cues by reinforcing perceived authenticity and trust, particularly in markets with relatively low organic market development. Integrating organic certification with origin labelling and transparent supply chain practices may therefore enhance both consumer trust and the structural reduction of fraud risk in honey markets. In this broader context, food fraud vulnerability extends beyond technical and regulatory shortcomings to include organizational, social, and structural factors, such as differences in control capacity, power relations, and the distribution of fraud-related risks across food value chains (Huisman and van Ruth, 2022; Lord et al., 2022).

An important finding of this study is the substantially larger utility coefficients estimated for the Italian sample compared with the other country models. Because the RPL models were estimated separately for each country, the absolute magnitude of the coefficients should not be interpreted as evidence of stronger preferences. Instead, differences in coefficient size may reflect differences in the scale of the estimated utility, which is inversely related to the variance of the unobserved component of utility. Larger coefficients may therefore indicate that Italian respondents made more consistent choices with less random variation rather than valuing every attribute more strongly. Cross-country differences in purchasing habits, familiarity with honey quality attributes, and market structure may have contributed to more consistent preference patterns among Italian consumers. Consequently, the results should be interpreted primarily in terms of the direction and relative importance of attributes within each country rather than by directly comparing coefficient magnitudes across countries.

5. Limitations and future research

These findings should be interpreted in light of several limitations. First, the discrete choice experiment relies on hypothetical purchase scenarios, which may result in differences between stated preferences and actual market behaviour. Accordingly, the willingness-to-pay

estimates are derived from ratios of estimated utility coefficients in a hypothetical setting and should therefore be interpreted as indicators of relative consumer valuation rather than precise market premiums. Future research could complement stated preference approaches with revealed preference data or experimental purchasing settings to assess whether consumers' willingness to pay for authenticity and traceability attributes translates into actual purchasing behaviour.

Another limitation of this study is that data were collected using an online panel, which may not fully represent the broader population in each country. In addition, socio-cultural differences across the countries may have influenced respondents' preferences and their interpretation of the attributes presented in the choice experiment. These factors, together with variation in the experimental context, mean that willingness-to-pay estimates should be compared across countries with caution. Accordingly, the WTP results are most appropriately interpreted within each country rather than as directly comparable absolute values across all settings.

Although data were collected from multiple European countries, the findings should not be interpreted as representing a single European consumer perspective. Instead, the results provide insights into consumer responses within individual national contexts that differ in terms of market conditions, cultural factors, and institutional environments. The observed heterogeneity across countries suggests that consumer preferences and the value placed on assurance attributes vary substantially across European markets, limiting the ability to formulate general recommendations for the EU as a whole. Furthermore, due to differences in the experimental design across countries, particularly the package size presented to respondents, a pooled model was not employed. While a pooled approach could have provided estimates of aggregate European-level preferences, it may also have masked important country-specific differences. Future research using harmonised experimental designs across countries and applying pooled or hierarchical modelling approaches could provide insights into both overall European consumer patterns and cross-country heterogeneity.

The technical nature of the adulteration testing attribute may also have made it more difficult for respondents to evaluate. Unlike more tangible attributes such as origin or direct sales, testing for adulteration involves an invisible verification process whose meaning and implications may not have been immediately apparent to all consumers. As a result, some respondents may have found it challenging to fully assess the value of this attribute within the choice task.

Finally, this study focuses on consumer preferences for authenticity and traceability attributes and does not assess the technical performance, effectiveness, or real-world implementation of specific authentication systems in reducing food fraud. Consequently, the findings should not be interpreted as evidence of the operational feasibility or fraud detection capability of particular technologies. Future research should integrate consumer preference and willingness-to-pay analyses with technological validation studies that evaluate detection capability, robustness, implementation feasibility, cost, and usability across different supply chain actors to provide a more comprehensive assessment of authentication and traceability solutions.

6. Conclusions

This study provides cross-country evidence on consumer preferences and willingness to pay for honey attributes related to authenticity, quality, and transparency. Across the studied countries, geographical origin emerged as the most consistently valued attribute, highlighting its importance as a signal of honey quality and authenticity. Consumers also expressed positive willingness to pay for verified origin (traceability), organic certification, and selected supply chain characteristics, confirming that trust plays a central role in honey purchasing decisions.

For supply chain actors, these findings suggest that investments in credible authentication and traceability systems may support product differentiation and could help offset implementation costs through

consumer willingness to pay. However, these findings reflect consumer preferences rather than direct evidence that such measures reduce food fraud or are economically viable under real-world conditions. Accordingly, authentication and traceability should be considered as components of broader quality assurance and governance strategies rather than standalone solutions.

Future research should examine whether stated willingness to pay translates into actual purchasing behaviour, whether price premiums are sufficient to compensate for implementation costs, and how readily authentication systems can be adopted and used across the supply chain.

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Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

The authors used ChatGPT (OpenAI, GPT-5.5) to assist with language editing, improving grammar, clarity, and readability of the manuscript. The authors reviewed, revised, and take full responsibility for the final content.

Ethical statement

The present study was part of a Horizon-funded project. Voluntary consumers participated in an online survey addressing their perception, experiences and preferences with food fraud. The study was approved by the Ethics Committee of the Department of Food System Sciences, Research Institute of Organic Agriculture, Frick, Switzerland after having been checked for compliance with [SRA Research Ethics Guidance \(2021\)](#). All participants were informed about the purpose of the study and provided informed consent before participation. No personal identifying information was collected.

CRediT authorship contribution statement

Hanna Stolz: Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Lucija Lapuh:** Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Cristina Laurenti:** Writing – review & editing, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Aira Joy Aquino:** Writing – original draft, Visualization, Software, Methodology, Formal analysis, Conceptualization. **Dávid Szakos:** Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Formal analysis, Conceptualization. **Gyula Kasza:** Writing – review & editing, Visualization, Validation, Software, Resources, Methodology, Funding acquisition, Formal analysis, Conceptualization. **Olivier Ejderjan:** Writing – review & editing, Supervision, Resources, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence

the work reported in this paper.

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Supplementary materials

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Data availability

Data will be made available on request.

References

- Aaker, D. A., Kumar, V., & Day, G. S. (2001). *Marketing research*. Wiley.
- Balco, P., Jaafer, F., & de Magistris, T. (2022). Investigating the price effects of honey quality attributes in a European country: Evidence from a hedonic price approach. *Agribusiness*, 38(4), 885–904.
- Baloš, M.Ž., Popov, N., Jakšić, S., Mihaljev, Ž., Pelić, M., Ratajac, R., & Pelić, D. L. (2023). Sunflower honey—Evaluation of quality and stability during storage. *Foods (Basel, Switzerland)*, 12(13), 2585. <https://doi.org/10.3390/foods12132585>
- Bouzembrak, Y., & Marvin, H. J. P. (2016). Prediction of food fraud type using data from Rapid Alert System for Food and Feed (RASFF) and bayesian network modelling. *Food Control*, 61, 180–187. <https://doi.org/10.1016/j.foodcont.2015.09.026>
- Caswell, J. A., & Mojduszka, E. M. (1996). Using informational labeling to influence the market for quality in food products. *American Journal of Agricultural Economics*, 78(5), 1248–1253.
- Cheng, J., Zhang, G., Abdulla, W., & Sun, J. (2024). Advancing fraud detection in New Zealand Manuka honey: Integrating hyperspectral imaging and GANomaly-based one-class classification. *Food Bioscience*, 60, Article 104428. <https://doi.org/10.1016/j.fbio.2024.104428>
- ChoiceMetrics. (2024). *NGene 1.2 tool to generate experimental designs for stated choice experiments* (Version 1.2) [Computer software]. ChoiceMetrics. <https://www.choice-metrics.com>.
- Ciursa, P., Oroian, M., Ciursa, P., & Oroian, M. (2021). Voltammetric E-tongue for honey adulteration detection. *Sensors*, 21(15), 5059. <https://doi.org/10.3390/s21155059>
- Conroy, D. M., & Lang, B. (2021). The trust paradox in food labelling: An exploration of consumers' perceptions of certified vegetables. *Food Quality and Preference*, 93, Article 104280.
- Contini, C., Boncinelli, F., Piracci, G., Scozzafava, G., & Casini, L. (2023). Can blockchain technology strengthen consumer preferences for credence attributes? *Agricultural and Food Economics*, 11(1), 27.
- Coral, C., & Mithöfer, D. (2025). Integrating social vulnerability into food fraud vulnerability assessment: Policy implications for authenticity in Spanish honey. *Food Policy*, 136, Article 102954. <https://doi.org/10.1016/j.foodpol.2025.102954>
- Darby, M. R., & Karni, E. (1973). Free competition and the optimal amount of fraud. *The Journal of Law and Economics*, 16(1), 67–88.
- De Canio, F., & Martinelli, E. (2021). EU quality label vs organic food products: A multigroup structural equation modeling to assess consumers' intention to buy in light of sustainable motives. *Food Research International*, 139, Article 109846. <https://doi.org/10.1016/j.foodres.2020.109846>
- Dhar, R., & Simonson, I. (2003). The effect of forced choice on choice. *Journal of Marketing Research*, 40(2), 146–160. <https://doi.org/10.1509/jmkr.40.2.146.19229>
- European Commission. (2023). *Food fraud*. Knowledge for Policy. https://knowledge4policy.ec.europa.eu/food-fraud-quality/topic/food-fraud_en.
- European Commission. (2024). *Honey Market Presentation* https://agriculture.ec.europa.eu/document/download/c04a9774-5ba3-41f5-b256-08396b2888ec_en?filename=market-presentation-honey_autumn2024_en.pdf&prefLang=sv.
- European Parliament and Council. (2001). *Council Directive 2001/110/EC of 20 December 2001 relating to honey* <https://eur-lex.europa.eu/eli/dir/2001/110/oj/eng>.
- European Parliament and Council. (2017). *Regulation (EU) 2017/625 of the European Parliament and of the Council* (Regulation (EU) 2017/625) <http://data.europa.eu/eli/reg/2017/625/2025-01-05>.
- European Parliament and Council. (2024). *Directive (EU) 2024/1438 of the European Parliament and of the Council* <https://eur-lex.europa.eu/eli/dir/2024/1438/oj/eng>.
- European Union. (2022). *Beekeeping sector: Results of the pilot study on honey bee selection*. Directorate-General for Agriculture and Rural Development. 15 March 2022 https://agriculture.ec.europa.eu/news/beekeeping-sector-results-pilot-study-honey-bee-selection-2022-03-15_en.
- Eurostat. (2024). *Population on 1 January by age and sex*. Eurostat. <https://doi.org/10.2908/DEMO.PJAN>.
- Fekete, L., Szabó-Bódi, B., Szakos, D., Süth, M., Oláh, J., Illés, C. B., & Kasza, G. (2025). Positioning of the high-quality food trademark in Hungary through consumer

- segmentation. *Journal of Agriculture and Food Research*, 24, Article 102466. <https://doi.org/10.1016/j.jafr.2025.102466>
- Fernqvist, F., & Ekelund, L. (2014). Credence and the effect on consumer liking of food – A review. *Food Quality and Preference*, 32, 340–353. <https://doi.org/10.1016/j.foodqual.2013.10.005>
- Ge, L. (2022). To buy or not to buy? A research on the relationship between traceable food extrinsic cues and consumers' purchase intention. *Frontiers in Psychology*, 13, Article 873941.
- Gossner, C., Schlundt, J., Embarek, P., Hird, S., Lo-Fo-Wong, D., Beltran, J., Teoh, K. N., & Tritscher, A. (2009). The Melamine Incident: Implications for international food and feed safety. *Environmental Health Perspectives*, 117, 1803–1808. <https://doi.org/10.1289/ehp.0900949>
- Greene, W. (2016). *NLOGIT (Version 6) [Computer software]*. Econometric Software, Inc.
- Gustafson, C. R., Champetier, A., Tuyizere, O., & Gitungwa, H. (2024). The impact of honey fraud information on the valuation of honey origin: Evidence from an incentivized economic experiment. *Food Control*, 155, Article 110070.
- Hair, J. F., Bush, R. P., & Ortinau, D. J. (2003). *Marketing research: within a changing information environment*. McGraw-Hill/Irwin.
- Hemmert, G. A. J., Schons, L. M., Wieseke, J., & Schimmelpennig, H. (2018). Log-likelihood-based pseudo-R² in logistic regression. *Sociological Methods & Research*, 47(3), 507–531. <https://ideas.repec.org/a/sae/somere/v47y2018i3p507-531.html>
- Hristov, H., Erjavec, K., Pravst, I., Juvancić, L., & Kuhar, A. (2023). Identifying differences in consumer attitudes towards local foods in organic and national voluntary quality certification schemes. *Foods (Basel, Switzerland)*, 12(6), 1132. <https://doi.org/10.3390/foods12061132>
- Huisman, W., & van Ruth, S. (2022). Risky business: Food fraud vulnerability assessments. *Crime, Law and Social Change*, 78(5), 559–576.
- IBM Corp. (2020). *IBM spss statistics for windows (Version 24.0) computer software*. IBM Corp.
- Kasza, G., Izsó, T., Langsrud, S., Vrbos, D., Veflen, N., Ueland, Ø., Scholderer, J., Minter, L., Csenki, E., Szakos, D., Ramsay, J., & Süth, M. (2024). Institutional food safety risk communication – A self-evaluation tool and its interpretation. *Trends in Food Science & Technology*, 150, Article 104594. <https://doi.org/10.1016/j.tifs.2024.104594>
- Kwasi Bannor, R., Arthur, K. K., Oppong, D., & Oppong-Kyeremeh, H. (2023). A comprehensive systematic review and bibliometric analysis of food fraud from a global perspective. *Journal of Agriculture and Food Research*, 14, Article 100686. <https://doi.org/10.1016/j.jafr.2023.100686>
- Lancaster, K. J. (1966). A new approach to consumer theory. *Journal of Political Economy*, 74(2), 132–157. <https://doi.org/10.1086/259131>
- Lord, N., Flores Elizondo, C., Davies, J., & Spencer, J. (2022). Fault lines of food fraud: Key issues in research and policy. *Crime, Law and Social Change*, 78(5), 577–598.
- Louviere, J. J., & Lancia, E. (2009). Choice experiments in health: The good, the bad, the ugly and toward a brighter future. *Health Economics, Policy, and Law*, 4(Pt 4), 527–546. <https://doi.org/10.1017/S1744133109990193>
- Lusk, J. L., & Schroeder, T. C. (2004). Are choice experiments incentive compatible? A test with quality differentiated beef steaks. *American Journal of Agricultural Economics*, 86(2), 467–482. <https://doi.org/10.1111/j.0092-5853.2004.00592.x>
- Manara, V., Zacepins, A., Brodschneider, R., Tlak Gajger, I., Kasza, G., Meana Mañes, A., Kozmus, P., Vejsnæs, F., Charistos, L., Fabricius Kristiansen, L., Splitt, A., Toporcak, J., Danneels, E., Traynor, K., Simon Delso, N., Jannoni Sebastianini, F., & Formato, G. (2026). First attempt to identify and prioritise best beekeeping practices with a multi-actor approach in the EU. *Journal of Apicultural Research*, 65, 69–79. <https://doi.org/10.1080/00218839.2025.2576979>
- Marín, X., Grau-Noguer, E., Gervilla-Cantero, G., Ripolles-Avila, C., & Castillo, M. (2025). Emerging technologies for detecting food fraud: A review of the current landscape in the 2020s. *Trends in Food Science & Technology*, 165, Article 105313. <https://doi.org/10.1016/j.tifs.2025.105313>
- McFadden, D., & Train, K. (2000). Mixed MNL models for discrete response. *Journal of Applied Econometrics*, 15(5), 447–470. [https://doi.org/10.1002/1099-1255\(200009/10\)15:5<253C447::AID-JAE570%253E3.0.CO;2-1](https://doi.org/10.1002/1099-1255(200009/10)15:5<253C447::AID-JAE570%253E3.0.CO;2-1)
- Moore, G., Brooks, P., Pappalardo, L., & Boufridi, A. (2025). Phenolic profiles of Australian monofloral eucalyptus, *Corymbia*, *Macadamia* and *Lophostemon* honeys via HPLC-DAD analysis. *Food Chemistry*, 462, Article 140900. <https://doi.org/10.1016/j.foodchem.2024.140900>
- Moyer, D. C., DeVries, J. W., & Spink, J. (2017). The economics of a food fraud incident – Case studies and examples including melamine in wheat gluten. *Food Control*, 71, 358–364. <https://doi.org/10.1016/j.foodcont.2016.07.015>
- OECD. (2024). *Portugal*. OECD Better Life Index. <https://www.oecdbetterlifeindex.org/countries/portugal/>
- Oravec, T., Mucha, L., Magda, R., Totth, G., & Illés, C. B. (2020). Consumers' Preferences for locally produced honey in Hungary. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 68(2), 407–418. <https://doi.org/10.11118/actaun202068020407>
- Pocol, C. B., Šedík, P., Glogovečan, A.-I., & Brumă, I. S. (2022). Traceability issues of honey from the consumers' perspective in Romania. *International Food and Agribusiness Management Review*, 25(5), 709–722. <https://doi.org/10.22434/IFAMR2021.0145>
- Razpotnik, B., & Žnidarič, M. (2021). *The number of households and families up*. Slovenia: Households and Families, 1st January 2021 <https://www.stat.si/StatWeb/pr/News/Index/9973>
- Risius, A., Janssen, M., & Hamm, U. (2017). Consumer preferences for sustainable aquaculture products: Evidence from in-depth interviews, think aloud protocols and choice experiments. *Appetite*, 113, 246–254. <https://doi.org/10.1016/j.appet.2017.02.021>
- Rocchi, B., Romano, D., Sadiddin, A., & Stefani, G. (2020). Assessing the economy-wide impact of food fraud: A SAM-based counterfactual approach. *Agribusiness*, 36(2), 167–191. <https://doi.org/10.1002/agr.21633>
- Schrobback, P., Zhang, A., Loechel, B., Ricketts, K., & Ingham, A. (2023). Food credence attributes: A conceptual framework of supply chain stakeholders, their motives, and mechanisms to address information asymmetry. *Foods*, 12(3), 538. <https://doi.org/10.3390/foods12030538>
- Schulze, M., Spiller, A., & Risius, A. (2021). Do consumers prefer pasture-raised dual-purpose cattle when considering meat products? A hypothetical discrete choice experiment for the case of minced beef. *Meat Science*, 177, Article 108494. <https://doi.org/10.1016/j.meatsci.2021.108494>
- Šedík, P., Hudecová, M., & Predanócyová, K. (2023). Exploring consumers' preferences and attitudes to honey: Generation approach in Slovakia. *Foods (Basel, Switzerland)*, 12(10), 1941.
- Social Research Association (SRA). (2021). *Research ethics guidance* <https://the-sra.org.uk/SRA/SRA-Resources/ethics.html>
- Sparacino, A., Merlino, V. M., Blanc, S., Borra, D., & Massaglia, S. (2022). A choice experiment model for honey attributes: Italian consumer preferences and socio-demographic profiles. *Nutrients*, 14(22), 4797.
- Spence, M. (2002). Signaling in retrospect and the informational structure of markets. *The American Economic Review*, 92(3), 434–459. <https://www.jstor.org/stable/3083350>
- Spink, J., Moyer, D. C., & Speier-Pero, C. (2016). Introducing the Food Fraud initial screening model (FFIS). *Food Control*, 69, 306–314. <https://doi.org/10.1016/j.foodcont.2016.03.016>
- Statistisches Bundesamt. (2024). *Statistisches bundesamt*. Destatis. https://www.destatis.de/EN/Home/_node.html
- Thøgersen, J. (2023). How does origin labelling on food packaging influence consumer product evaluation and choices? A systematic literature review. *Food Policy*, 119, Article 102503. <https://doi.org/10.1016/j.foodpol.2023.102503>
- Tonsor, G. T., & Shupp, R. S. (2011). Cheap talk scripts and online choice experiments: "Looking beyond the mean. *American Journal of Agricultural Economics*, 93(4), 1015–1031. <https://doi.org/10.1093/ajae/aar036>
- Train, K. E. (2009). *Discrete choice methods with simulation* (2nd ed.). Cambridge University Press. <https://doi.org/10.1017/CBO9780511805271>
- Traoré, O. Z., Tamini, L. D., & Korai, B. (2023). Willingness to pay for credence attributes associated with agri-food products—Evidence from Canada. *Canadian Journal of Agricultural Economics/Revue Canadienne d'agroeconomie*, 71(3–4), 303–327. <https://doi.org/10.1111/cjag.12336>
- Walker, M.L., Burns, M., & Burns, D.T. (2013). 'Horse meat scandal'; or 'horsegate' am. 41, 67–106.
- Wang, H., Cao, X., Han, T., Pei, H., Ren, H., & Stead, S. (2019). A novel methodology for real-time identification of the botanical origins and adulteration of honey by rapid evaporative ionization mass spectrometry. *Food Control*, 106, Article 106753. <https://doi.org/10.1016/j.foodcont.2019.106753>
- Wang, Z., Tsafara, A., Arhondakis, S., Dourou, A.-M., Moraiti, S., Nolan, S., Cultrera, N. G. M., Passeri, & Argyropoulos, D. (2026). Food fraud screening and vulnerability assessment in the olive oil supply chain. *Applied Food Research*, Article 101916.
- Wu, W., Zhang, A., van Klinken, R. D., Schrobback, P., & Muller, J. M. (2021). Consumer trust in food and the food system: A critical review. *Foods*, 10(10), 2490. <https://doi.org/10.3390/foods10102490>
- Ždiniaková, T., Lörchner, C., De Rudder, O., Dimitrova, T., Kaklamanos, G., Breidbach, A., Respaldiza, A., Silva, V., Ines, M., Paiano, V., Ulberth, F., & Maquet, A. (2023). *EU coordinated action to deter certain fraudulent practices in the honey sector: analytical testing results of imported honey*. Publications Office of the European Union. <https://data.europa.eu/doi/10.2760/184511>
- Zhou, X., Taylor, M. P., Salouros, H., & Prasad, S. (2018). Authenticity and geographic origin of global honeys determined using carbon isotope ratios and trace elements. *Scientific Reports*, 8(1), Article 14639. <https://doi.org/10.1038/s41598-018-32764-w>
- Zaletelj T.O., Rojc, N., Vratnar, H. (2021). Unemployment rate remains below 5%. Labour Force Survey Results, Slovenia, 3rd Quarter 2021. <https://www.stat.si/StatWeb/en/News/Index/9979>