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Research article

Blockchain for the valorization of Made in Italy extra virgin olive oil: A discrete choice experiment on young consumers

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Abstract: The authenticity and traceability of Italian extra virgin olive oil (EVOO) are key consumer concerns, particularly considering counterfeit products threatening the Made in Italy brand. Italian EVOO is distinguished by its low acidity and unique polyphenolic and aromatic composition, which contribute to its high quality and health benefits. Considering the new Italian law for the protection of the Made in Italy brand, blockchain technology could become a viable instrument to improve transparency and ensure the uniqueness and excellence of Italian EVOO. This study examined young Italian consumers' preferences for blockchain-traced EVOO using a labelled discrete choice experiment. The objective was to assess their willingness to pay for blockchain-enabled traceability and its influence on purchasing behavior. Data were collected via an online survey with 245 participants aged 18–40, and the results were analyzed using a random parameter logit model to account for preference heterogeneity. Findings reveal a strong preference for Italian-origin EVOO, with blockchain-certified products receiving a positive consumer response. The analysis also indicates that consumers are willing to pay a premium for blockchain-traced EVOO, particularly when combined with Italian origin. These results highlight the potential of blockchain technology in strengthening consumer trust and protecting Made in Italy products.

Keywords: blockchain; extra virgin olive oil; consumer; made in Italy; choice experiment

1. Introduction

The food and beverage Made in Italy brand is acknowledged worldwide for producing high-quality goods, supported by the manufacturing proficiency found within a network of small firms and artisanal tradition [1]. With over 850 goods featuring the origin certification and a revenue of over 20 billion euros, Made in Italy agri-food production constitutes a fundamental pillar of the national economy [2].

Recently, awareness regarding the origin and authenticity of food products has increased, as these factors are becoming crucial in assessing and influencing consumers' preferences in food purchasing decisions [3]. In this sense, the Made in Italy concept embodies a genuine array of values, securing a significant competitive advantage due to the benefits arising from its solid image. It is a mark of origin that conjures a favorable feature that defines Italy's national image in the minds of consumers and enables them to differentiate between domestic and imported products [1]. Nevertheless, the Made in Italy brand endures significant losses because of imitations and counterfeits, owing to the widespread appeal and esteemed quality of Italian food products [4].

To try to curb the threats to the authenticity of Made in Italy products, in 2023, Law 206 came into force for the valorization, promotion and protection of Made in Italy products as identity factors and drivers of economic growth, stimulating the development of national strategic supply chains and combating counterfeiting [5]. This law identifies blockchain technology as an innovative instrument for improving traceability and enhancing the Made in Italy supply chain, ensuring the completeness and reliability of information accessible to consumers. Blockchain is a digital technology based on a distributed ledger whose properties can be exploited to record the history of one or more products throughout the entire supply chain. The integrity of the data is safeguarded by a very high level of cryptographic protection, which, combined with the system's automatic ability to detect tampering, makes alteration virtually impossible [6,7].

Extra virgin olive oil (EVOO) is a pivotal food product recognized by the 2023 Made in Italy law, and it is among those for which blockchain can signify a transformative advancement in affirming the Italian provenance of productions. It is among several agri-food products deemed exemplary of Made in Italy, requiring that both the production methods and, primarily, the raw materials be authentically sourced from Italy to attain this designation [8]. Italy is the second largest producer of olive oil in the world [9], and about one-third of the total national production is represented by EVOO [10]. The Italian olive oil sector is mainly composed of small or medium-sized enterprises [11]. In fact, in Italy, there are 619,000 olive farms cultivating 1.14 million hectares of olive groves. Those farms produced 328 thousand tons of olive oil in 2023, of which between 2% and 4% were destined for products with quality labels, such as Protected Designation of Origin and Protected Geographical Indication. Despite the large quantities produced, these are not sufficient to meet the national market demand; in 2023, the apparent consumption of olive oil was 489 thousand tons [12]. To meet the needs of the domestic market, Italy relies on imports from other countries, including Spain, Tunisia, and Turkey [9].

As with all Made in Italy products, the quality of the raw materials is the primary determinant of the final product. Italian EVOO is distinguished by its acidity of less than 0.8% (as mandated by European laws) and its unique polyphenolic and aromatic composition. These components subsequently affect the characteristics of EVOO, which, due to its effects, is a fundamental element of the Mediterranean diet. Monounsaturated fatty acids, such as oleic acid, assist in regulating the immunological response, whereas polyphenols, due to their antioxidant qualities, exhibit antitumor, antiviral, and anti-inflammatory actions [13–15]. Consequently, the source of the raw materials is a

crucial factor for Italian consumers when selecting EVOO [16]. A Nielsen IQ-ISMEA survey revealed that 47% of Italians regard origin as the primary attribute when buying it [12]. Indeed, sales of 100% Italian EVOO in large-scale retail distribution rose from 2021 to 2024 [17]. Nonetheless, EVOO is also plagued by problems regarding falsification of the provenance of raw materials [18–20], compromising the product's reputation and perceived quality [10,21,22]. The intrinsic mechanism of blockchain can ensure the authenticity of information for consumers [23], hence fostering enhanced loyalty towards Italian olive oil producers. Such information may be accessed via a QR code on the bottle, which, when scanned, provides supply chain traceability from the olive grove to the table [24–26].

The implementation of innovative traceability systems in the food supply chain necessitates more focus on younger consumer groups. This is because young individuals generally have enhanced awareness and curiosity about innovative digital and internet tools, including blockchain technology [27,28]. Individuals in younger age groups are more inclined to choose products certified by blockchain, demonstrating stronger positive intentions towards blockchain-traceable information within the food supply chain than older generations, highlighting their considerable influence on shaping the future of the food industry [3,25,29,30].

Moreover, young consumers perceive foods with local or national origins as highly satisfactory and of superior quality, even if this quality is linked to a higher price [31–33]. Connecting younger generations interested in food provenance with blockchain technology for traceability could be particularly beneficial in safeguarding and promoting the Made in Italy culture for EVOO. Therefore, this study seeks to examine the purchasing preferences and willingness to pay (WTP) for Italian EVOO tracked via blockchain technology among young Italian consumers aged 18–40. To achieve this objective, we conducted a labelled discrete choice experiment (DCE) and evaluated the results using a random parameter logit (RPL) model. To our knowledge, just two previous studies had investigated the interaction of olive oil consumers with blockchain [28,34]. Different from our paper, Violino et al. [28] conducted an economic analysis examining the preferences of Italian consumers and their WTP for three different types of digital traceability, including blockchain technology. On the other hand, Masmoudi and Gargouri [34] assessed the factors influencing consumer choices regarding blockchain-traced olive oil using linear regression analysis. Instead, our study seeks to enhance the literature about consumer perceptions of blockchain applications, specifically inside the EVOO supply chain rather than in the agri-food sector broadly. The study may benefit those olive oil producers considering the adoption of new technologies, but who remain uncertain about the investment's value, considering customers' openness to and willingness to pay a premium for blockchain-traced EVOO. This article is structured into five sections. Following this introduction, Section 2 details the methodology, describing the questionnaire and methodology used to collect data, the design of the DCE and the model used. Section 3 presents the results. Section 4 comprises the discussion, and Section 5 presents the conclusions.

2. Materials and methods

2.1. Discrete choice experiment

The DCE technique is a quantitative approach based on Lancaster's [35] characteristics of value theory, which posits that any good may be characterized by a set of attributes and their respective levels. Grounded in the random utility framework [36], it employs statistical design theory to create

choice cards where respondents select their preferred option from a set of mutually exclusive alternatives distinguished by their attributes and levels. By manipulating the degrees of attributes among alternatives and incorporating a monetary attribute, one can evaluate the overall value of a modification in a good, as well as the value of its constituent attributes. These values are not stated directly but instead are indirectly recovered from people's choices. A baseline or opt-out option must be incorporated to render the economic choice more realistic, hence preventing the issue of respondents being compelled to select options they may not favor.

The DCE was selected as it facilitates the estimation of the relative significance of various product qualities, the trade-offs among these attributes, and individual preferences for each product type. Moreover, the inclusion of price among the product attributes allows researchers to estimate the marginal WTP for each attribute. By examining the trade-off between the chosen attributes and levels, it is possible to obtain the individuals' utility in a choice situation [37–40]. There are two main groups of DCE: unlabeled DCE and labeled DCE [41]. Unlabeled DCEs employ generic designations for the alternatives. Labeled DCEs utilize specified titles for the options. A labeled DCE was utilized in this work. This methodology enables respondents to assess product qualities and concurrently compare product alternatives [42]. Comparative judgment is a crucial aspect of consumer quality perception, since it illustrates the interactions between the consumer and the product [43,44].

The DCE framework posits that the indirect utility function for each respondent can be divided into two components: a deterministic element and a stochastic element. This is shown in equation (1):

$$U_i = V(x^i, s) + \varepsilon_i \tag{1}$$

Where U_i represents the utility of the i^{th} alternative, $V(x^i, s)$ is a function of the observed characteristics of the i^{th} alternative (x^i) and the observed characteristics of the respondent (s), and ε_i is a random component that is not observed.

When an individual is presented with a choice between two alternatives (*i* and *k*), it is presumed that they evaluate the utility they could derive from each option and thereafter select the alternative that offers the most utility. An error term is provided because responders may evaluate the selections based on knowledge beyond what is presented, including all potential alternatives available to the individual. Due to the presence of an error component in the utility function, predictions cannot be made with certainty. Consequently, the analysis transforms into a matter of probabilistic selection. The probability that a certain respondent favors option *i* above any alternative option *k* can be articulated as the probability that the utility linked to option *i* surpasses that of all other alternatives, as delineated in Equations (2) and (3):

$$P(i|C) = P(U_i > U_k) \qquad (k \neq i) \tag{2}$$

$$P(i|C) = P[\varepsilon_k - \varepsilon_i < V(x^i, s) - V(x^k, s)] \qquad (k \neq i) \tag{3}$$

To derive an explicit expression for this probability, it is necessary to know the distribution of the error terms (ε_i). Assume that ε_i has a reciprocal exponential (Weibull) distribution, so it is distributed identically and independently across all alternatives [Equation (4)].

$$P(\varepsilon_i < t) = exp(-\varepsilon^{-t}) \tag{4}$$

Given this assumption, it is possible to derive a multinomial logit model (MNL) to determine the choice probabilities, as stated in Equation (5):

$$P(i|C) = \exp V(x^i, s) \,/ \sum_{j \epsilon C} expV(x^j, s) \quad (5)$$

Where $P(i|C)$ is the choice probability for alternative i in a finite choice set (C), x^i is the vector of the observed characteristics of alternative I, and s is the vector of the observed characteristics of the respondent.

The MNL is widely used as it generates simple closed-form expressions for choice probabilities, and the results can be easily interpreted. However, this model fails to account for the heterogeneity of individual preferences and presumes the independence of irrelevant alternatives (IIA). Consequently, modifications in the characteristics of any product i, or the entrance of a new product into the selection set, cannot affect the relative probability of choosing an alternative j and k. This is evidently implausible in instances where product i bears greater resemblance to j than to k [45].

To avoid the IIA problem, a widely used model is the RPL. In the RPL, the individuals' utility for choosing alternative i in a choice scenario C is given by Equation (6):

$$U_{niC} = (\beta + \eta_n)x_{niC} + \varepsilon_{niC} \quad (6)$$

Where β is the vector of mean attribute utility weights in the population, η_n is the vector of person n-specific deviations from the mean, and ε_{niC} is the stochastic term, assumed to be independent and identically distributed extreme value. The RPL allows capturing preference heterogeneity by randomizing the coefficients of β among respondents [39,46]. It addresses the independence of IIA by employing a flexible variance-covariance structure for the stochastic term [47]. These attributes enhance model fit [48] and our comprehension of choice behavior [49]. Given this assumption, it is possible to derive an RPL to determine the choice probabilities, as stated in Equation (7):

$$P(i|X_{nC}) = \frac{1}{D}\sum_{d=1}^{D} \exp\left[(\beta + \eta^d)x_{niC}\right] / \sum_{k=1}^{1} \exp\left[(\beta + \eta^d)x_{nkC}\right] \quad (7)$$

Where X_{nC} is the vector of attributes of all alternatives I = 1,…, I.

Lastly, the total WTP of a product i versus the baseline alternative ("none of the presented products") was calculated as the difference between the marginal utilities of an alternative divided by the marginal utility of the price parameter, as expressed in Equation (8):

$$WTP_i = - \beta_i / \beta_{price} \quad (8)$$

The determination of WTP is possible because the price coefficient is a monetary one [50]. The confidence intervals of the WTPs are calculated by the Krinsky and Robb parametric bootstrapping method [51]. The data analysis was conducted using NLOGIT 5.0 software. The coefficients, WTP, and their confidence intervals were estimated with 10,000 random draws.

2.2. Attribute selection and experimental design

The preliminary stage of developing a DCE involved identifying relevant attributes for our study and subsequently determining the levels for each attribute. The characteristics of the hypothetical EVOO bottles were obtained from a literature review of consumer preferences for olive oil and consultations with diverse stakeholders. The literature review was conducted on Scopus, using the following search string: "(olive and oil) and (choice and experiment)". From this search, 95 documents

emerged. Of these, only 87 were in English. Subsequently, articles were selected based on the analysis of the title and abstract to assess their actual relevance by a team of three researchers. The final result was 18 valid articles, used for the selection of attributes. The most recent of these articles is from 2023 [52], followed by two articles from 2021 [53,54], four articles from 2020 [55–58], three articles from 2019 [59–61], one article from 2016 [62], one article from 2015 [63], and two articles from 2014 [64,65]. The remaining articles predate 2012 [66–69]. Regarding the consulted stakeholders, interviews were conducted with Italian EVOO producers and producer organizations to evaluate any attributes of their interest. The label selected for this research is "blockchain", while the two attributes selected are "origin" and "price".

The blockchain feature was chosen as the label in the DCE because it is specifically mentioned in Italian Law 206/2023 on the protection of Made in Italy [5]. This law supports the growth and use of this technology to improve the Italian EVOO supply chain. Blockchain in the EVOO supply chain could be an interesting innovative technology to control origin and protect traditional knowledge. Blockchain, in fact, makes all the steps of the supply chain visible and transparent, thus ensuring traceability [19,70]. From the interviews conducted with the producers, an interest in this technology emerged, but it was tempered by doubts about its effectiveness in attracting consumers. A challenge with the implementation of blockchain technology in EVOO may pertain to consumer acceptance. EVOO is a classic food product in Italy, and customers perceive the introduction of innovation for this product as discordant [71]. For traditional food products, the innovations that seem most successful are those that offer specific benefits to consumers, such as improvements in convenience, without compromising the traditional nature of the product [72]. Blockchain, therefore, could have enormous potential in helping to build consumer loyalty and attract new consumer groups such as younger generations [73]. Yet, to the authors' knowledge, only two articles have analyzed the relationship between olive oil consumers and blockchain [28,34]. Violino et al. [28] directly asked the interviewees which traceability methodologies they preferred and how much they were willing to pay. In their analysis, they observe that the proposed blockchain system with a QR code can be an attractive technology from the consumer's perspective. The authors justify the result, on the one hand, by its reward mechanism and gamification approach and, on the other hand, by its easy access to information through QR codes. Masmoudi and Gargouri [34] applied a Unified Theory of Acceptance and Use of Technology 2, finding that consumers' propensity towards blockchain technology is linked to their level of trust, and olive oil traceability is still struggling to gain customers' acceptance.

No article has applied the choice experiment to analyze the willingness to purchase blockchain-traced EVOO. For this reason, in our choice experiment, we decided to propose this attribute as the representative label of the product, expressed as the presence or absence of blockchain. The presence of the blockchain in the choice set was indicated through a logo created by the authors.

The origin attribute in this analysis was divided into three levels: "100% Italian olive oil", "blend of olive oils of EU origin", and "blend of olive oils of non-EU origin". The origin attribute was chosen because EVOO literature shows it as one of the most important attributes to consumers. It is, indeed, a complex quality indicator linked to concepts such as typicality and ethnocentrism, incorporating various other criteria, including safety and traceability [58].

The importance of this attribute emerges both in countries where olive oil consumption is relatively recent [56,68] and in countries where this product is a staple of the diet, such as France and Tunisia [66], Spain [52,55,59,62], and Italy [54,58–60]. For Italian consumers, the country of origin holds significant intrinsic value, as Italy's image is compared with the production attributes associated

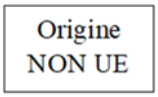
with Made in Italy, which invokes distinct expertise and traditions [1,74]. In fact, the production of olives and EVOO in Italy, in terms of the agronomic scenarios and varieties used, is quite varied. Production is carried out by small producers and mills throughout the national territory [11], with necessary differences in olive and olive oil production corresponding to the distinct qualities of each geographical region. This leads to a great variety of specific EVOOs, characterized by different nutritional and organoleptic characteristics, in relation to their region of origin [75].

Additionally, the country-of-origin label is mandatory in European EVOO bottles (according to the Commission Delegated Regulation (EU) 2022/2104 [76]) and, among the other mandatory information, is probably the most recognizable [54].

The last attribute, price, is the conventional economic variable that adversely affects consumer demand and is a critical attribute frequently employed in choice experiments [52,54]. The inclusion of the price is essential for estimating WTP and for making consumer choices more realistic. In this study, the different price levels were obtained through a market analysis conducted in June 2024 on the various types of EVOO available on the Italian market. In line with the literature [52,54,55,59], we chose to propose three price levels. Three price levels were chosen to provide more realistic choices, in line with the Italian EVOO market, and to cover the range where respondents are expected to have preferences [52]. In the Italian market, olive oil is characterized by different price ranges. In this article, therefore, it was decided to propose the lowest value found in the market as the minimum price and the highest value as the maximum price. The intermediate range was determined by averaging the prices. Specifically, the three price ranges proposed in the choice were €9.00/L, reflecting the cheapest EVOO, €13.00/L, reflecting an average price, and €19.00/L for a higher quality oil.

Table 1 summarizes the attributes proposed in the choice cards and the corresponding levels.

Table 1. Experimental attributes and levels in the choice experiments (source: authors' elaboration).

Attributes	Levels	Labels
Blockchain certification	Yes	
	No	
Origin	Italy	
	EU	
	NON-EU	
Price (€/L)	€9.00/L	
	€13.00/L	
	€19.00/L	

After the definition of attributes and level, STATA 15.0 software was used to generate an

efficient experimental design for estimating the main effects with 9 choice sets selected (D efficiency = 0.908). In the choice set, there was also an opt-out option: "neither of the products presented". This option made the analysis more consistent with the demand theory and made the choice more realistic, since it allowed the respondents to act as they would in real market situations. Moreover, in the choice set, the olive oil proposed was clearly labelled as "EVOO" and offered in 0.75-L bottles. This size was selected since it is the most widely available for EVOO in the Italian market. An example of a choice set is shown in Figure 1.

1. Quale di questi oli extra vergine di oliva comprerebbe? Se non è interessato o i prezzi le sembrano troppo alti, può scegliere l'opzione di non acquisto.

- o A
- o B
- o Non li acquisterei

Figure 1. Example of a choice set (where "Quale di questi oli extravergine di oliva comprerebbe? Se non è interessato o i prezzi le sembrano troppo alti, può scegliere l'opzione di non acquisto" is the Italian translation of "Which of these extra virgin olive oils would you buy? If you are not interested or if the prices seem too high to you, you can choose the option of not purchasing". "Olio Extra Vergine di Oliva" is the Italian translation of Extra Virgin Olive Oil, and "Non li acquisterei" is the opt-out option) (source: authors' elaboration).

The attributes and levels associated with the proposed options were presented individually before the choice options through a brief text. This text and figure-based explanation helped clarify the characteristics and differences between the proposed attributes to all respondents, thereby reducing any potential biases [77]. Moreover, to reduce hypothetical bias, a cheap talk script was presented to respondents [78,79]. In the cheap talk, participants were asked to try to respond without bias to the DCE, trying to actively put themselves in a real shopping situation.

In the RPL, the presence or absence of blockchain certification is the alternative-specific constant (ASC). Random parameters were allocated to the ASC as they encompass all product aspects not evaluated comprehensively. In this analysis, ASCs (ASC_BCTY, ASC_BCTN) were represented as dummy variables and presumed to follow a normal distribution throughout the population, as consumers may have preferences for or aversions to each type of EVOO. The "origin" property was effect-coded with "blend of olive oils of non-EU origin" as the reference level and was assumed to follow a normal distribution. At last, we calculated a coefficient for the EVOO price, which was deemed fixed (i.e., non-random) to guarantee finite distribution moments for the WTP.

2.3. Survey and data collection

The data were collected through an online questionnaire consisting of four sections. The first part of the survey gathered data on the consumption patterns of EVOO among respondents, including purchase frequency, purchasing locations, and the degree of attention given to the label. The second part included questions concerning the significance of traceability for the interviewees and their understanding of blockchain, followed by a definition of the technology. The Italian translation of the following blockchain definition was proposed:

"The term *blockchain* refers to a computer or digital service that enables a company to track the movement of its goods from the field to the table over every step of the supply chain. This makes it possible to follow the olive oil's full path, guaranteeing data openness and verifying its authenticity. Following the recording of product data, the system can generate a QR code, or digital label, that allows the consumer to track the product, read the supply chain story, and verify details about production, processing, and cultivation. Both the manufacturer and the consumer are safeguarded by this framework".

The third section comprised the cheap talk and the DCE task. The last section collected information about the participants' socio-demographic characteristics.

Data were collected between July 1, 2024, and September 1, 2024. We gathered the sample from the Italian population, aged between 18 and 40 years, who took (partial) responsibility for grocery shopping in their household and consuming EVOO. The average time to complete the questionnaire was 10 minutes. We conducted two pre-test sessions on the questionnaire before its official release. The outcomes of the pre-tests were utilized to elucidate certain questions, incorporate new ones, eliminate others, and generally enhance the whole questionnaire.

3. Results

3.1. Descriptive analysis of the sample

A total of 321 individuals participated in the questionnaire. 53 responses were excluded due to respondents indicating they do not purchase EVOO, and 18 responses were deleted because the data provided was incomplete or inaccurate. Thus, the ultimate sample utilized for the investigation comprised 245 persons.

The sample was made up of 50% men and 50% women, and the average age of the respondents was 26. The level of education of the sample was high, as about 69% had a degree or a postgraduate education. The average size of households was around three, and the most widespread average annual

income was between €21,000 and €35,000 (37%). Table 2 shows the socio-demographic characteristics of the sample.

Table 2. Socio-demographic characteristics of the sample (source: authors' elaboration).

Variables	Categories	Value	Variables	Categories	Value
Gender	Male	50%	Age	18–25 years	53%
	Female	50%		26–30 years	25%
Household	< €10,000	11%		31–35 years	13%
annual net	€11,000–€20,000	24%		36–40 years	9%
income	€21,000–€35,000	37%	Education	Middle school	2%
	€36,000–€50,000	19%		High school	29%
	€51,000–€75,000	4%		Graduation	59%
	> €76,000	5%		Postgraduate	10%
Household size	Average	3.21			

Among the respondents, 30% said they consume EVOO frequently, and about 58% said they consume it every day. The most common place where respondents purchase EVOO is supermarkets (58%). Around 25% of the sample indicated that they buy from local producers and 10% that they buy from olive oil mills. Most of the sample (72%) indicated that, on average, they spent between €7 and €10 for a 0.75-L bottle of EVOO. However, 18% of respondents said they spent more than €10 per bottle.

The respondents indicated, using a Likert scale from 1 (not important) to 5 (very important), that the most significant factor at the time of purchase was origin (4.06 ± 1.05), followed by organoleptic characteristics (3.75 ± 1.13), and price (3.67 ± 1.06). The presence of awards was the variable with the lowest reported score (1.78 ± 1.07) (Figure 2).

The questionnaire also inquired whether participants typically read the labels on EVOO. 31% reported that they never or rarely read the labels, 28% sometimes read them, and 41% indicated that they often or always read them. This suggests that most participants (69%) pay attention to the information provided on the product's label.

Finally, we investigated how much participants knew about the importance of traceability for food safety and whether they had heard of blockchain technology. In the sample, 99% considered traceability important for food safety, and 51% said they were familiar with blockchain.

Proceeding to the findings of the choice experiment, Figure 3 illustrates the selection frequencies for the various proposed attributes. The percentage was calculated by dividing the number of times an attribute was chosen by the number of times it was proposed in the choice cards.

The sample selected blockchain-traced products more frequently than non-traced products (41% and 30%, respectively). In the origin attribute, the most selected level was Italy (61%), followed by Europe (44%), and a small percentage of non-European Union origin (12%). Within the price attribute, the most selected level was €13/L (55%), followed by €9/L (32%) and €19/L (23%). Finally, around 29% of the choices involved refusing to purchase the proposed options.

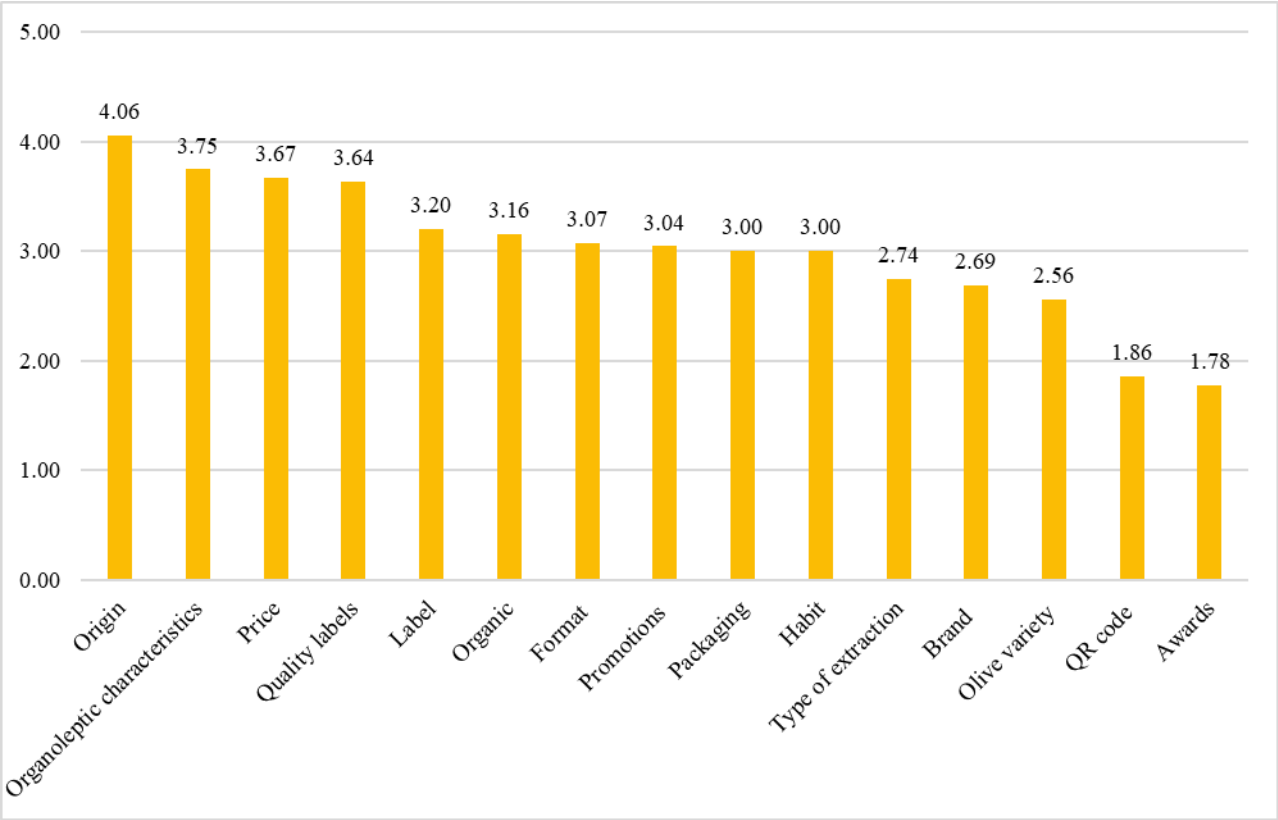


Figure 2. Declared factors influencing the choice of EVOO at the time of purchase (source: authors' elaboration).

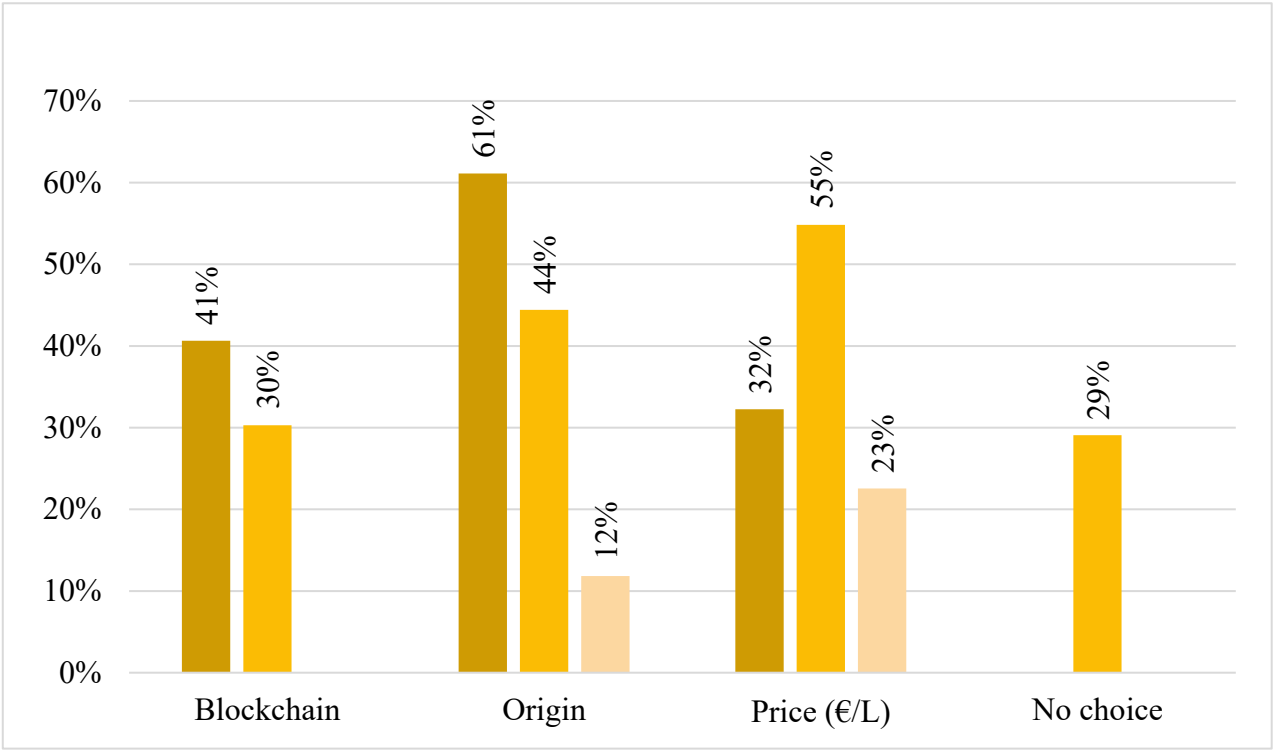


Figure 3. Total percentage of choice for each attribute in all choice sets (source: authors' elaboration).

3.2. Random parameter logit model output

The results from the RPL model (Table 3) show that the two alternatives, "Blockchain yes" and "Blockchain no", were statistically significant and had a positive coefficient. This indicates that consumers preferred both alternatives over the option of no choice.

Regarding the attributes related to origin, both Italian and European coefficients were statistically significant. However, the coefficient for Italian origin was positive while the coefficient for European origin was negative. These results indicate that, in line with the literature [54,58,60,61], origin influences Italian consumers when choosing EVOO. The respondents favoured Italian provenance as the preferred indication of origin during the selection process. The European origin of EVOO was less favoured than both the non-choice and the non-European origin.

As expected, the effect of price on the choice of different EVOOs was statistically significant with a negative coefficient. This outcome demonstrates that increased prices diminished the demand for all varieties of EVOO, consistent with demand theory. This underscores the credibility of the results and suggests that the participants in our trials engaged with the task seriously.

Table 3. Random-parameter logit model output (source: authors' elaboration).

Choice	Coefficient	Standard error	z	Prop. |z|>Z*	95% confidence interval		
Random parameters in utility functions							
ITA	3.0744	0.1918	16.03	0.0000	2.6985	3.4503	***
EU	−0.4453	0.0980	−4.54	0.0000	−0.6374	−0.2532	***
ASC-BCTY	3.1149	0.2896	10.76	0.0000	2.5473	3.6824	***
ASC-BCTN	1.0958	0.2455	4.46	0.0000	0.6147	1.5769	***
Non-random parameters in utility function							
P	−0.2802	0.0173	−16.20	0.0000	−0.3141	−0.2463	***
Standard deviations of the random parameters							
NsITA	1.3547	0.1508	8.98	0.0000	1.0591	1.6502	***
NsEU	0.7281	0.1086	6.71	0.0000	0.5154	0.9409	***
NsBCTY	1.7867	0.1642	10.88	0.0000	1.4649	2.1085	***
NsBCTN	1.6889	0.1853	9.11	0.0000	1.3257	2.0522	***

Note: ***, **, *: Significance at 1%, 5%, 10%; ASC-BCTY: Alternative-specific constant blockchain yes; ASC-BCTN: Alternative-specific constant blockchain no; P: Price vector.

Finally, the standard deviations of the random parameters were all found to be significant. This outcome signifies that the respondents' choices were heterogeneous, reflecting different preferences within the sample. This result indicates that the MNL would have been insufficient to represent the choice behavior. Thus, it was established that the selected RPL model exhibited greater accuracy and more effectively represented the preferences of respondents compared to an MNL.

After the estimation of the RPL model, using the parameters calculated as stated in Equation (8), the WTP for each attribute was estimated (Table 4).

Table 4. WTP estimated from the RPL model (source: authors' elaboration).

Choice	Coefficient	Standard error	Prop. |z|>Z*	
WTP for each specific attribute				
ITA/P	10.97	0.55	0.0000	***
EU/P	−1.59	0.32	0.0000	***
BCTY/P	11.12	0.62	0.0000	***
BCTN/P	3.91	0.75	0.0000	***
WTP for EVOO with different attribute combinations				
BCTY - ITA	23.68	0.96	0.0000	***
BCTN - ITA	16.47	0.86	0.0000	***
BCTY - UE	−1.44	0.89	0.1039	
BCTN - UE	−8.65	1.16	0.0000	***

Note: ***, **, *: Significance at 1%, 5%, 10%; BCTY: Blockchain Yes; BCTN: Blockchain No; P: Price vector.

The attribute for which individuals exhibited the highest WTP was the presence of blockchain, with a coefficient of €11.12/L. Italian origin ranked second, valued at €10.97/L.

After estimating the value of each individual attribute, the value of the product under different scenario assumptions with various combinations of attributes was assessed. Only the combinations with the indication of Italian origin showed a positive WTP. The greatest WTP was identified for the EVOO characterized by Italian provenance verified using blockchain (€23.68/L). A WTP of €16.47/L was identified for the non-traced Italian EVOO. The WTP values found in the analysis were deemed reliable and in line with the actual prices observed in the market. In fact, the average market price of a non-traceable Italian EVOO is €16/L. While at the time of the analysis, there are still a few EVOO oils tracked with blockchain, the WTP of €23.68/L is higher than the highest price found on the shelf of €19/L.

4. Discussion

The purpose of this article was to examine the preference of young consumers for EVOO, with particular attention to traceability achieved through blockchain.

The origin has clearly emerged as one of the factors that most influence young Italian consumers at the time of choice. The importance of this attribute emerged both among the factors declared by the interviewees and in the results obtained from the DCE. This result was widely anticipated; in fact, according to the literature, Italian EVOO consumers consider origin the most significant attribute when making a choice, with a particular preference for local or national origin [54,58,60,61]. The significance of origin for Italian consumers may stem from Italy's status as an olive oil-producing nation, leading to a perception of the product as "something of our own" [80]. Italian consumers are familiar with EVOO and are accustomed to associating the sensory attributes of EVOO with cultivars and agronomic practices; hence, awareness of provenance provides consumers with confidence regarding the product's flavor profile [63,81]. In particular, the Made in Italy label evokes in the minds of consumers a series of positive attributes that characterize the image of Italy as a country, thus representing a set of values for them [1]. Italian consumers actively look for quality information and, in addition to assessing product labels, certifications, and official quality schemes, they seek a more direct relationship with producers. They evaluate specific factors such as the type of olives, various aspects of the production process, the size and nature of the producer, and relevant features of the production area [10].

Although the article by Giannocaro et al. [60] associates the preference for Italian food with older consumers, the results of our analysis, in line with the literature [63,82,83], demonstrate that this attribute is inter-generational and of great importance even for young consumers. This may be associated with the increasing significance of short supply chains as a decisive element in the purchasing preferences of young consumers [84,85], as local food consumption is regarded as sustainable, healthful, and ecological [86].

Moving on to the results related to the blockchain attribute, the analysis revealed that, although almost the entire sample considers traceability a key element for food authenticity, only a little over half of the respondents (51%) had previously heard of blockchain technology. This was an expected result, as already noted in literature on the application of blockchain technology in the agri-food sector [87]. The consumers' limited knowledge of technology is linked to its relatively recent adoption in the agri-food sector [88]. However, once informed about the characteristics of this technology, at the time of choice, the interviewees preferred blockchain-traced EVOO over non-traced EVOO. This result is consistent with the literature, where other agri-food products such as beer [80], beef [89–91], rice [92], and milk [93] were tested. It can therefore be inferred that, despite the recent spread of this technology in the agri-food sector, it can generate a positive attitude and interest among consumers. Consumers are demanding more and more transparency and accountability from food producers [94], and the blockchain fully meets these needs. Moreover, young consumers seem to be the ideal target for Italian EVOO tracked with blockchain. First, they are more likely to be pioneers in accepting innovation in the agri-food sector [27–29]. At the same time, they are increasingly guided by the origins of products at the time of purchase, as they perceive foods with local or national origins as highly satisfying and of superior quality [31–33]. Blockchain in this context could be the ideal technology to meet the needs of young Italian consumers in consuming Made in Italy EVOO, ensuring transparency and reliability. This would create new important opportunities for producers, opening them up to increasingly significant market niches of consumers attentive to quality and sustainability associated with the image of Made in Italy.

Lastly, the findings regarding WTP indicate that respondents acknowledged a positive value only for products labeled as Italian. This outcome reinforces the previously mentioned significance of the Made in Italy brand for young Italian consumers of EVOO and aligns with existing literature, which highlights Italians' willingness to pay a premium for Made in Italy EVOO [54,60,61,64]. Moreover, it could also be related to the high level of education among the sample. The literature has indeed demonstrated a strong relationship between a higher level of education and the likelihood of being willing to pay a premium price for Made in Italy products [95].

A second interesting aspect that emerged from the WTP analysis is that the highest premium price was noted when the attributes Italian origin and blockchain traceability were presented simultaneously. The interviewees indeed confirmed a willingness to pay approximately €4.68/L more for an Italian-origin EVOO traced with blockchain, compared to the highest price currently on the market for Italian EVOO, i.e., €19.00/L. This result is consistent with previous literature [88], which emphasizes that, despite most consumers having limited knowledge of blockchain, regardless of their level of education, once informed about the existence of the technology, they show a greater WTP [96]. Moreover, the positive WTP of young people for blockchain-traced EVOO is in line with the results of Violino et al. [28] and is linked to the propensity of young consumers for new technologies. Those results reflect the perceived value of blockchain in ensuring food safety and quality. Blockchain could be an effective tool for enhancing and protecting Made in Italy products, increasing consumer trust in the brand while simultaneously certifying the quality of the product by making the raw materials used and the

transformations undergone by the product transparent [34,80,88,97]. The application of blockchain, therefore, could represent a key element in increasing young consumers' trust in Italian EVOO.

5. Conclusions

This work provides both analytical and empirical contributions to the literature on blockchain adoption within the agri-food supply chain. From a methodological point of view, this is the first study that utilizes the DCE to analyze the consumer behavior towards the use of blockchain for tracing EVOO. The main result emerging from the analysis is that digital traceability implemented with blockchain, in addition to combating fraud, can help consumers distinguish between "standard" EVOO and high-quality EVOO with specific organoleptic and nutraceutical characteristics linked to the territory of origin.

The empirical contribution of the paper comprises an increase in information on young consumer attitudes towards the technology and an enhanced understanding of consumer perceptions of its positive characteristics. The results show that consumers did not fully know about blockchain. However, once they became aware of it, they chose it. It can be deduced that better communication is essential to increase younger consumer awareness. The results related to WTP could be encouraging for entrepreneurs who decide to apply blockchain technology. The recognition of a premium price by the interviewees has a dual impact on farmers. On the one hand, companies could benefit from blockchain to gain a competitive advantage in the market by promoting their product and their authenticity. On the other hand, the application of the technology could be too expensive for small companies; however, the awareness of the presence of a premium price could represent an incentive to invest in this technology.

Policymakers in Europe, but particularly in Italy, have already taken steps to promote and disseminate this technology, especially in the EVOO sector. However, this technology is still little known by producers, and therefore further efforts are needed to increase the dissemination of this technology.

Despite the encouraging findings of this study, including consumers' willingness to pay a premium for EVOO traced via blockchain, it is crucial to acknowledge the considerable challenges that may impede the adoption of this technology by Italian producers. First and foremost is the issue of cost: whether implemented through third-party platforms or proprietary systems, blockchain adoption requires substantial financial investment, which remains difficult to sustain for many small and medium-sized enterprises in the olive oil sector. In addition, the absence of clear regulatory frameworks at the European level for blockchain applications in the agri-food industry creates uncertainty, discouraging adoption. Technical challenges also arise from the integration of blockchain with existing traceability and farm management systems. This process can be complex and resource-intensive, particularly due to the generally low level of understanding regarding blockchain technology. Furthermore, the current digital infrastructure is often insufficient to handle the high volume and complexity of data associated with a fragmented supply chain like that of EVOO, particularly when using public blockchains, which may also face scalability and speed limitations. These barriers point to the need for further research to assess economic feasibility and to facilitate the broader implementation of blockchain-based traceability solutions in the olive oil industry.

Some limitations of the study should be highlighted. A primary criticism of DCE is hypothetical bias, wherein individuals consistently overestimate their reported WTP. To address this issue, we instituted several ex-ante methods in the survey prior to the value estimation. First, we provided them with a cheap talk. Second, we offered prices determined by a market analysis of probable competitors,

emulating an actual price scenario. Future studies in this field may employ mixed-method approaches to yield a more holistic comprehension of consumer behavior through the integration of qualitative and quantitative data. Moreover, longitudinal research would facilitate the examination of the evolving characteristics of consumer preferences and market dynamics over time. Implementing these methodological modifications can empower future research efforts to address the constraints found in our study and contribute more effectively to the advancement of knowledge in the domain of blockchain traceability in olive oil. Finally, the limitation of the sample to Italy may constrain the generalizability of the findings, particularly as it exclusively involves young people. Future research should broaden the sample both demographically and geographically, fostering greater interest in technology and its use to enhance the export potential of Made in Italy agri-food goods.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

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Conflict of interest

All authors declare no conflicts of interest in this paper.

Author contributions

Giacomo Staffolani: conceptualization, data curation, formal analysis, methodology, software, writing—original draft; Giulia Chiaraluce: conceptualization, investigation, validation, writing - original draft, writing—review and editing; Deborah Bentivoglio: conceptualization, formal analysis, methodology, supervision, validation, writing—review and editing; Bruno Vodo: conceptualization, data curation, investigation, visualization, writing—original draft; Pier Paolo Miglietta: conceptualization, supervision, validation, writing—review and editing; Adele Finco: conceptualization, funding acquisition, project administration, supervision.

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