



Research Article

Exploring Consumer Insights on Food Product Traceability in Portugal

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Abstract

In today's fast-changing food industry, consumer expectations around safety, quality, and transparency push for more effective traceability systems. This study examines how Portuguese consumers perceive food product traceability, focusing on their awareness, trust, and preferences in product origin, production methods, and safety protocols. Through a survey, the socio-economic impact of advanced traceability systems was explored. The results show that most consumers consider traceability essential for ensuring food safety. However, a significant portion remains unaware of these systems. Factors such as product quality, price, and storage conditions were highlighted as top priorities when purchasing food, with traceability seen as a way to improve these aspects. Consumers are also intensely interested in information about product origins and transportation conditions, especially temperature control, as these directly affect safety and quality. This reflects growing concerns over foodborne illnesses and waste due to poor transportation practices. The research emphasises the need for greater consumer education on the value of traceability systems and the potential advantages of adopting digital traceability technologies. The study's originality lies in its specific focus on the behaviour of Portuguese consumers regarding food traceability, a topic that has been relatively underexplored in this context.

Keywords: Traceability, food products, BIOma project, consumers, Portugal

Introduction

Consumers increasingly seek sufficient information to make informed purchasing

decisions about food products. However, in this sector of activity, this is not always possible due to market failures such as information asymmetry between buyers and sellers. This asymmetry is included in consumers' perception

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of risk as they develop strategies and value the tools that allow them to reduce such risk (Bauer, 1967; Choe et al., 2009). An example of a strategy to reduce the perception of risk associated with food consumption is the introduction in many economies of a Food Traceability System, which provides all relevant information about the food process "from farm to fork".

In 1998, Wilson and Clarke (1998) defined food traceability in the agricultural-based food chain as the information needed to describe the production history of a food crop and any subsequent transformations or processes that the crop may undergo on its way from the field to the consumer's plate. More recently, Olsen and Borit (2013), taking into account ISO standards, redefined traceability as the ability to access all information related to the product throughout its life cycle, information that is recorded and can be accessed later than its collection. Bosona and Gebresenbet (2013) refine this definition and apply it to food products. According to these authors, food traceability is defined as a part of logistics management that captures, stores, and transmits the appropriate information about the food product at all stages of the food chain so that the product can be verified regarding safety and quality control.

Under European legislation, and more specifically Article 3 of Regulation (EC) No 178/2002 of the European Parliament and the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety, traceability is the possibility of tracing food, feed, and animal intended for food production or a substance designed to be incorporated into food or feed or likely to be used as such, through all stages of production, processing and distribution. In short, agri-food traceability refers to tracking the movement and origin of food products along the entire supply chain, from the farm to the consumer. It, therefore, involves the recording and documenting of information at various stages of the production, processing, distribution and trade of food products. Islam and Cullen (2021) compile multiple definitions of traceability, presenting the motivations and beneficiaries of food traceability and synthesising the existing typologies and principles of a traceability process so that its implementation is carried out efficiently and effectively. The authors point out

that traceability is a generic construct because its fundamentals are independent of the type of product, production, and control system it serves.

Although the legislation does not indicate which type of analytical tool to use in the traceability process (François et al., 2020), the traceability process typically involves the use of technologies such as barcodes, QR codes, RFID (radio frequency identification) or blockchain technologies (Pappa et al., 2018) to record and track relevant information about the product at each stage. This information may include details about the farm, production date, and processing methods, storage conditions or transport details. A traceability system shall: (i) identify products, product batches, shipping units and storage units; (ii) establish the link between the batches and the shipping unit over successive steps; (iii) record data by predetermining the recorded information; and, (iv) communicate the information to the next actor to ensure the continuity of the information generation process (Qian et al., 2020; Olsen and Borit, 2018; 2013). Therefore, a reliable traceability system enables quick and efficient responses to any issues that may arise during the production or distribution of food products. It ensures a continuous flow of information throughout the food chain by utilising a data recording system that tracks each step of a product's journey. Such a system ensures that key product details, particularly identification, are consistently communicated through proper labelling, accompanying documentation, or stored information throughout the value chain. This allows for a comprehensive understanding of the product's entire history.

The literature on the topic (Islam and Cullen (2021), Demestichas et al. (2020), Qian et al. (2020), Creydt and Fischer, (2019) and Aung and Chang (2014a), for instance) states that regardless of the techniques and tools in the traceability process, it is vital in the agri-food sector for several reasons, including:

- (i) Food safety, as the traceability process, helps to identify the source of any potential foodborne illnesses or incidents and, in the event of contamination, affected products can be quickly identified, located and withdrawn from the market, preventing the spread of the problem and protecting public health;

- (ii) Quality control: by following the entire physical flow associated with the production and supply chain of the food product, it is easier and faster to identify and mitigate problems related to product quality, allowing producers and distributors to improve their production and distribution processes and offer consistency in the quality of their offer;
- (iii) Regulatory compliance: the process of tracking a product facilitates compliance with regulations (usually stringent regarding food safety and product labelling) and the commitment to generate and maintain the appropriate documentation required during inspections and audits;
- (iv) Access to international markets: as in many developed economies, there are specific import requirements, such as the imposition of very high non-tariff barriers to imports, so traceability can increase the export possibilities of agri-food products;
- (v) Consumer confidence: adopting transparent traceability systems instils confidence and security in consumers, giving them access to information about the origin, production and transport methods and safety of their food products.

For the reasons mentioned above, traceability systems play a crucial role in ensuring food safety, quality and transparency throughout the agri-food supply chain, benefiting both businesses and consumers. An example of the importance of traceability in the food sector is found in the fruit and vegetable sector. This sector faces increasing international competition due to the globalisation of markets, and the current challenge for players is to become sufficiently competitive in terms of price, traceability, quality and safety to avoid food scandals and fraud (François et al., 2020). For consumers of agri-food products, in particular, traceability is vital because it allows them to gather information on the product's origin, the practices used in its production and transport, and any transformations it has undergone along the supply chain. Specifically, the following are the aspects where traceability can play a vital role for the consumer (Zhang et al, 2020; Aung and Chang, 2014a):

- (i) Food safety: traceability helps ensure the safety of agri-food products by

enabling the identification, tracing, and recall of contaminated and unsafe food products in the event of foodborne outbreaks or illnesses, breaking the distribution chain of these products and protecting the end consumer by avoiding potential risks to their health. In this way, consumers and society benefit directly by bearing fewer health-related expenses (medical expenses and productivity decline);

- (ii) Quality assurance: The traceability process gives consumers the confidence to purchase and consume a product because the system allows them to identify the origin and route of the food product and that it complies with quality standards and regulations. More likely, consumers will purchase products that meet their expectations, increasing their satisfaction and reducing costs with returns or complaints;
- (iii) Transparency and trust: traceability promotes transparency in the supply chain, allowing the consumer to have information regarding the methods of production, processing and distribution of food products, and thus to assess ethical, environmental, and social aspects of food production. This information fosters trust in the food supply chain, increasing consumer loyalty and willingness to pay higher prices;
- (iv) Allergen management is critical to bridging the information asymmetry many consumers face with food allergy problems. With a robust traceability process, it is possible for the consumer to know the origin and processing history of a food product and can avoid accidental exposure to allergens, as well as cross-contamination during production, processing, packaging and/or distribution;
- (v) Origin and authenticity: with the development and recognition of the importance of the agri-food sector, there is also a growing concern about food fraud or inaccuracies in labelling. A traceability process allows consumers to verify the origin and authenticity of products and their certification;
- (vi) Sustainability and environmental impact: Traceability allows consumers to choose products with sustainable practices, such as fair trade

certifications or environmentally friendly farming methods, which are key aspects of the new consumer behaviours observed in developed economies where consumers are becoming more environmentally conscious and looking for products with a lower environmental impact;

- (vii) Compliance and Regulations: Food safety and quality regulations often require traceability in various countries. Complying with these regulations ensures that producers adhere to correct standards and practices, leading to the marketing of safer and higher-quality products for consumers;
- (viii) Consumer empowerment: Traceability gives consumers a voice in the food system. By demanding traceability, consumers influence companies to adopt more responsible practices and improve the overall responsibility of the agri-food industry.

In summary, the traceability of agri-food products plays a crucial role in providing consumers with valuable information, helping them make informed choices, and protecting them from deceptive or fraudulent practices. This, in turn, boosts consumer confidence, enhances decision-making, and promotes a safer, more sustainable, food supply with reduced environmental impact. Traceability also improves the accuracy and trustworthiness of food labels. Enabling product identification and tracking ensures the integrity of labels and maintains the distinctiveness of specific products. As a result, the implementation of traceability systems strengthens the connection between consumers and food products by making the product's history transparent and reducing perceived risks, making it a vital component of the modern food industry.

Dopico et al. (2016) and Dopico (2015) agree that traceability is an effective tool to ensure food safety in the food chain. This tool simultaneously improves supply chain management, product quality, product differentiation, and the reduction of customer complaints, and it can be advantageous during the storage and transport of food products. Carriers and storage operators must comply with the requirements laid down in Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002, as their activity is covered by the definitions set out in

Article 3(2) and (3) of that Regulation. An adequate and well-adjusted traceability system enables the identification of products or groups of products throughout the food chain, providing numerous advantages. In alignment with the European Union's Regulation, a traceability system allows for:

- (i) Generating control over raw materials, products, and processes, which enables the faster and more selective removal of products from the market in case of health issues, customer complaints, or production failures, thereby reducing costs (Charlier & Valceschini, 2008);
- (ii) Quickly determining the cause of the problem by reviewing documents and records containing information about suppliers, customers, transaction dates, product nature, origin, content, and quantity;
- (iii) Meeting the growing demand for information from consumers, who will feel more satisfied and confident in their products, ensuring transparency throughout the food chain (Kher et al., 2010);
- (iv) Enhancing consumer confidence, as efficient crisis management, can significantly reduce damage to the brand's commercial image (Casino et al., 2019);
- (v) Strengthening the trust between customers and suppliers by promoting more transparent relationships and better information exchange (Qian et al., 2020).

Considering the importance of the agricultural sector for the Portuguese economy and the previously defined aspects regarding the relevance of food-products traceability, namely from the consumer's perspective, a three-year scientific project - that gathered together universities and companies from all over the country - has been conducted. BIOma project aimed to position companies in the agri-food value chain at more competitive and sustainable levels. The project promoted adopting integrated bioeconomy solutions in the agri-food sector through strategic action and an innovative ecosystem. One of the solutions involved developing and implementing an integrated traceability solution for the agro-food value chain. As there were no consumers directly involved in the development of the solution, it is considered fundamental to understand their knowledge, understanding and perspective on

the development and implementation of a traceability solution (BIOma, 2023).

Methodology

In developing new tools for the traceability of agri-food products and, specifically, of tools that track the proper transport of these products, this research aims to describe Portuguese consumers' perception of traceability processes in the agri-food sector. It is intended to assess the potential socio-economic impact of implementing a traceability procedure that adds information on the product's distribution chain, specifically on the transport conditions of agri-food products.

To this end, a survey divided into two parts was prepared and applied presentially to visitors to the Agriculture Fair, which took place in Santarém in June 2023, where the traceability system developed within the scope of the BIOMA mobilising project was presented. When visiting the BIOMA project output, the participants were randomly invited to answer the survey anonymously. The survey, developed by the research team for this research-specific work, considering the literature on the topic, consists of two parts. In the first part, a set of four questions is presented that aim to characterise some sociodemographic characteristics of the participants in the study. These characteristics include gender, age, educational attainment, and family situation. In a second part, several questions are presented that aim to assess: (1) the degree of importance attributed to factors such as price, quality, nutritional composition labeling, packaging, identification of origin, storage conditions and labeling regarding the date of harvest and storage and transport conditions, at the time of acquisition of the agricultural product; (2) the importance attached by the consumer to the information contained on the packaging of agricultural products, including nutritional composition, date of production, expiry date, information on origin, conditions of transport and the possibility of obtaining additional information by telephone or website; (3) the importance attached to the traceability of food products; (4) the interest in knowing the history of storage and transportation of the agricultural products consumed; (5) the reasons to which the consumer attaches more importance in the traceability process; and, (6) what information the consumer would like to be able to obtain in the context of the traceability process.

The statistical data obtained constitute a *cross-section database* in which statistical information is presented for different variables at a given time (June 2023). A total of 124 valid answers were obtained, and these answers were the sample used in this study. The descriptive results will be presented in tables and figures, where the leading indicators of the statistical distribution of the results are presented. The absolute and relative distribution of the statistical values of the variables in the sample under study will be shown when the variables are divided into different categories, and indicators of central tendency (mean) and variability (minimum, maximum and standard deviation) of the distribution of the sample when the variables are measured on a 5-point Likert scale.

Results and Discussion

Table 1 shows the statistical distribution of the sample by sociodemographic characteristics – gender, age group, family and professional situation, and academic qualification of the participant. The table shows how the sample is distributed, in absolute value (n) and relative value (%), by each category considered by variable.

The sample primarily consists of women (79 respondents), making up nearly 64% of the group, while 45 men represent approximately 36%. The survey was conducted among adults, with 24% (30 individuals) aged between 18 and 30, 49% (61 individuals) between 31 and 50, and almost 26% (32 individuals) aged 51 to 70. Only one respondent (0.8%) was over 70 years old. A significant portion of the participants (52% or 64 individuals) are married or in a committed relationship, while 47.6% (60 individuals) are single, divorced, or widowed (0.8%). Regarding education, almost 88% hold a bachelor's degree or a specialised higher technical course (CTESP), with 0.8% holding master's degrees and 1.6% having a doctorate. Only one participant (0.8%) had basic education, while 11 (8.9%) completed secondary education. In terms of employment, the majority of participants are either employees (65.3%) or self-employed (13.7%), with 17% being students, 3.2% unemployed, and one respondent (0.8%) retired.

Table 1: Absolute and relative distribution of sociodemographic characteristics of the sample

Variáveis	Categories	Absolute Value	Relative Value
		(n)	(%)
Sex	Female	79	63.7
	Male	45	36.3
Age (age range)	18-30 years	30	24.2
	31-50 years	61	49.2
	51-70 years	32	25.8
	More than 70 years	1	0.8
Marital status	Married	64	51.6
	Single	59	47.6
	Widow	1	0.8
Academic qualification	Basic qualification	1	0.8
	Secondary qualification	11	8.9
	Higher education (bachelor)	109	87.9
	Master	1	0.8
	PhD	2	1.6
Employment status	Unemployed	4	3.2
	Employee	81	65.3
	Employer	17	13.7
	Student	21	16.9
	Retired	1	0.8

Source: Authors' own elaboration

The sociodemographic characterisation of the elements that make up the sample is important to understand, in a more detailed way, how consumers, according to some of their demographic and social characteristics, perceive and attribute importance to a process of traceability of the food products they consume. However, before starting the study of the importance given by national consumers to traceability processes, it is important to understand which factors they attribute more importance to in purchasing agricultural

products for food consumption. The degree of importance was measured on a Likert scale of 1 to 5 points, where 1 indicates that the factor is "not at all important" and 5 indicates that the factor is "extremely important". Table 2 shows the distribution of the results obtained by each specific factor. The table shows the minimum and maximum values selected by the sample elements, the mean results for the total sample, and the respective standard deviation. All members of the sample answered all the questions.

Table 2. Importance of factors influencing the consumer of food products at the time of purchase

Variables	n	Minimum	Maximum	Mean	Standard Deviation
Quality	124	2	5	4.49	0.781
Price	124	2	5	4.10	0.944
Informative labelling on nutritional composition	124	1	5	3.63	1.047
Source identification	124	1	5	3.63	1.100
Packaging	124	1	5	3.36	1.054
Storage conditions	124	1	5	4.06	0.990
Information labelling on harvest date, storage and transport conditions	124	1	5	3.65	1.128

Source: Authors' own elaboration

From the observation of Table 2, it is possible to see that all the elements mentioned in the survey: quality, price, nutritional labelling, packaging, storage conditions and information labelling on harvest date, storage and transport conditions are all important at the time of the decision to purchase the food product (all values are above 2.5 values on average). The quality (4.49), price (4.10), and storage conditions of agricultural products for consumption are the factors to which consumers attach most importance at the time of the purchase (4.06). It should be noted that none of the participants

reported that they consider the price or the quality of food products "not at all important". The same is not true for the other factors. The factor that participants give the least importance to is packaging. Information labelling on the date of harvest, storage, and transport conditions is considered an important factor. Still, it is only the fourth most important consumer factor when purchasing a food product.

Table 3 shows the results in Table 2 in more detail by dividing the results by women and men.

Table 3. Importance of factors influencing food consumers at the time of purchase by sex

Variables	n		Minimum		Maximum		Mean		Standard Deviation	
	W	M	W	M	W	M	W	M	W	M
Quality	79	45	2	3	5	5	4.544	4.400	0.781	0.780
Price	79	45	2	2	5	5	4.165	4.000	0.953	0.929
Informative labelling on nutritional composition	79	45	1	1	5	5	3.835	3.267	1.031	0.986
Source identification	79	45	1	1	5	5	3.684	3.533	1.104	1.100
Packaging	79	45	1	1	5	5	3.430	3.244	1.117	0.933
Storage conditions	79	45	1	2	5	5	4.139	3.911	1.034	0.900
Information labelling on harvest date, storage and transport conditions	79	45	1	1	5	5	3.810	3.356	1.122	1.090

Note: W stands for women, and M stands for men.

Source: Authors' own elaboration

The data reveal that women place greater importance on the factors under study than men. Across all aspects, the average importance ratings women give are consistently higher than those provided by men. Additionally, there is more variability in women's responses. However, both genders prioritize product quality, price, and storage conditions as the most important factors overall. While packaging is not among the top factors influencing consumers' food purchases, it is still valuable to understand

which aspects of packaging information consumers consider important. Table 4 outlines the results for each specific factor, showing the minimum and maximum values selected by participants, the average scores for the entire sample, and the standard deviations. Notably, all participants assigned some level of importance to each item in the survey. Table 5 provides a breakdown of the mean importance values for each sociodemographic category, offering a more detailed view of the data presented in Table 4.

Table 4. Importance given by consumers to the elements that make up the labelling of the packaging of a food product

Variables	n	Minimum	Maximum	Mean	Standard Deviation
Nutritional composition and energy value	124	1	5	3.80	1.020
Validity date	124	2	5	4.60	0.720
Production date	124	1	5	3.83	0.969
Access to additional information (via a telephone number or website)	124	1	5	2.80	1.028
Information on the origin of the product	124	1	5	3.69	0.991
Information on the conditions and duration of transportation from the origin to the point where you purchase the product	124	1	5	3.28	1.130

Source: Authors' own elaboration

The attribute consumers prioritise most on food packaging labels is the product's expiry date, with an average importance rating of 4.6 out of 5 among the 124 survey participants. Following this, consumers value information regarding the date of harvest or production, as well as the nutritional composition and energy value, each receiving an average rating of 3.8 out of 5. The least important, though still somewhat valued, is

access to additional information (such as a company's phone number or website). Consumers also give moderate importance to details about the conditions and duration of the product's transport from origin to the point of sale, with an average rating of 3.28 out of 5. However, this item shows a high degree of variability in responses, reflecting significant differences in how participants perceive its importance.

Table 5. Importance given by consumers to the elements that make up the labelling of the packaging of a food product – Average value by sociodemographic characteristics

Variáveis	Category	Nutritional composition and energy value	Validity date	Production date	Access to additional information (via a telephone number or website)	Information on the origin of the product	Information on the conditions and duration of transportation from the origin to the point where you purchase the product
(Average Value by category: 1 to 5 points)							
Sex	Female	3.92	4.56	3.81	2.85	3.71	3.28
	Male	3.58	4.67	3.87	2.71	3.64	3.29
Age (age range)	18-30 years	4.30	4.70	3.73	2.77	3.43	3.20
	31-50 years	3.64	4.56	3.90	2.80	3.70	3.30
	51-70 years	3.59	4.56	3.75	2.78	3.84	3.28
	More than 70 years	5.00	5.00	5.00	4.00	5.00	5.00
Marital status	Married	3.61	4.64	4.00	2.84	3.78	3.30
	Single	3.98	4.54	3.63	2.73	3.56	3.24
	Widow	5.00	5.00	5.00	4.00	5.00	5.00
Academic qualification	Basic qualification	5.00	5.00	5.00	4.00	5.00	5.00
	Secondary qualification	3.73	4.73	4.00	3.27	3.55	3.55
	Higher education (bachelor)	3.79	4.57	3.80	2.75	3.68	3.23
	Master	5.00	5.00	3.00	3.00	5.00	5.00
Employment status	PhD	3.50	5.00	4.50	2.00	3.50	3.00
	Unemployed	3.25	4.50	3.50	3.50	3.50	3.25
	Employee	3.77	4.62	3.98	2.84	3.84	3.36
	Employer	3.47	4.35	3.59	2.59	3.35	2.88
	Student	4.24	4.71	3.48	2.62	3.33	3.24
	Retired	5.00	5.00	5.00	4.00	5.00	5.00

Source: Authors' own elaboration

When asked about the significance of food traceability, the majority (85% or 105 participants) consider it important. However, 12 participants (about 10%) do not view traceability as necessary, and nearly 6% (7) are unfamiliar with the concept. The lack of

awareness regarding food traceability is not new, as previous studies by Dopico et al. (2016) and Chrysochoidis et al. (2006) have shown that many consumers lack sufficient knowledge about traceability. Table 7 compares responses between men and women on this topic.

Table 6. Absolute and relative distribution of participants' opinions on the importance of traceability of food products for consumption

Variáveis	Categories	Absolute Value	Relative Value
		(n)	(%)
Food traceability is important	I don't know what traceability of a food product is	7	5.7
	No	12	9.7
	Yes	105	84.7
	Total	124	100.0

Source: Authors' own elaboration

It is women who are more unaware of the traceability of food products (6.3% of women compared to 4.4% of men), and they are also the ones who indicate in a more significant percentage that they do not give importance to

the process (10.1% of women compared to 8.9% of men). However, both women (83.6%) and men (86.7%) mainly indicate that the traceability of food products is essential in their consumption.

Table 7. Absolute and relative distribution of participants' opinions on the importance of traceability of food products for consumption by sex

Variables	Categories	Absolute Value		Relative Value	
		W	M	W	M
		(n)		(%)	
Food traceability is important	I don't know what traceability of a food product is	5	2	6.3	4.4
	No	8	4	10.1	8.9
	Yes	66	39	83.6	86.7
	Total	79	45	100.0	100.0

Note: W stands for women, and M stands for men.

Source: Authors' own elaboration

Regarding the traceability process, the participants were asked two questions: one concerning the information they would like on the traceability of agri-food products and the other concerning the reason they consider most important to carry out a traceability process for the food products consumed. Participants in the study were asked to indicate what information they would like to see reflected in a traceability

process. Several options were suggested to the participants, including the origin of the product, the date of harvest, the storage time of the product (either at the producer or at the distributor), the type of transport carried out, the duration of the transport and the temperature at which the product was transported. Participants could simultaneously choose different types of information they would like to track in the agricultural products they consume. The answers are summarised in Table 8.

Table 8. Absolute and relative distribution of the answers obtained on the type of information the consumer wants to find with a traceability process

Variables	Categories	Absolute Value	Relative Value
		(n)	(%)
Product origin	Sim	107	86.3
	Não	17	13.7
	Total	124	100.0
Temperature at which the product was transported	Sim	89	71.8
	Não	35	28.2
	Total	124	100.0
Harvest date	Sim	88	71.0
	Não	36	29.0
	Total	124	100.0
Storage time (at the distributor)	Sim	80	64.5
	Não	44	35.5
	Total	124	100.0
Storage time (at the producer)	Sim	72	58.1
	Não	52	41.9
	Total	124	100.0
Type of transport carried out	Sim	52	41.9
	Não	72	58.1
	Total	124	100.0
Duration of transport	Sim	47	37.9
	Não	77	62.1
	Total	124	100.0

Source: Authors' own elaboration

In Table 8, it is possible to see that the information that consumers most often wish to have, following a process of traceability of food products for consumption, is information on the origin of the products consumed – 107 participants (about 86% of the total) say they wish to have this information. The following is information regarding the temperature at which the food product is transported – 89 participants (almost 72% of the total sample) report that this is the information they wish to have. The values of those who want information about the harvest date are very similar to those who want information about the temperature at which the product is transported – 88 (71%) of the participants are those who wish to have this information. The storage time at the distributor (80 participants, corresponding to 64% of the sample) and the storage time at the producer (72 participants, corresponding to about 58% of the sample) are the information that appears in 4th and 5th place in the ranking of information desired by consumers. With less than 50% of the sample reporting this type of information, there is information on the kind of transport carried out (only 52 of the participants mention it) and information on the duration of the transport (only 47 of the participants mention it).

In other words, after understanding the product's origin, it is essential for the consumers in this sample to have information about the conditions under which the transport is carried out until it reaches them. These conditions include the temperature at which the product is transported since the temperature can transform the organoleptic characteristics of the food product and, in this way, their quality and food safety.

Transport temperature plays a crucial role in the traceability of agri-food products. The perishability and temperature sensitivity of agri-food products are widely discussed in academic literature, industry publications and regulatory guidelines. See, for example, recent studies on this topic, such as Maiyar et al. (2023). These authors, citing data from the Centers for Disease Control and Prevention, state that in the United States of America (USA) alone 48 million people fall ill yearly due to foodborne illnesses. At the same time, according to the Food and Agriculture Organization of the United Nations (FAO, 2013), about one-third of fresh food is wasted every year along the supply chain after production due to poor transport and storage conditions and inadequate temperature and humidity control systems. Another work to

mention is that of Morais et al. (2019), who present the state-of-the-art and future trends in terms of sensor technologies for the traceability of food products, in particular concerning their storage and transport, to understand how such technologies can be applied in the traceability of vegetables to increase food quality and safety, Reducing food waste.

Many agri-food products, such as fruits, vegetables, dairy, and meat, are perishable and sensitive to temperature fluctuations. Hence, maintaining the correct transport temperature helps preserve these products' quality and safety (Aung and Chang, 2014a; 2014b). Deviations from the required temperature range can lead to spoilage, bacterial growth, or chemical reactions, compromising product quality and safety. As a result, governments and regulators often set specific temperature requirements for transporting certain food products. Thus, ensuring that the transport temperature meets these regulations is essential to meet compliance standards and avoid potential legal issues.

In addition to these aspects related to food safety and the rules and regulations to ensure such safety, it should be noted that temperature control during transport has significant economic consequences in economic terms (El Sheikha, 2019). For example, proper temperature control during transport can extend the shelf life of agri-food products (particularly crucial for products with short shelf lives) as it allows them to reach distant markets without significant degradation in quality. If this happens, and product recalls are required due to safety or contamination concerns, traceability through temperature records can help identify affected batches and simplify the recall process. This approach avoids unnecessary waste and minimises the impact on consumers (regarding their safety) and industry (regarding handling claims and costs). On the other hand, temperature monitoring during the traceability process allows for more efficient management of the supply chain and a more appropriate optimisation of logistics and distribution processes, i.e., better management of inventories (both in production and distribution) and the reduction of waste due to spoilage (Chaudhuri et al., 2018). In conclusion, the transport temperature significantly influences the traceability of agri-food products. By carefully monitoring and recording the temperature during transport, actors in the food supply chain can ensure the product's quality,

safety, compliance, and consumer satisfaction. Therefore, the result obtained in this study is fundamental to confirm the social and economic importance of the technology developed throughout this project. By giving importance to this aspect, the sample of Portuguese consumers surveyed agrees that traceability, including temperature monitoring, increases consumer confidence in the food supply chain. When consumers have access to information about the handling and transportation of agricultural products they consume, they can make informed choices and feel confident about the quality and safety of their purchases.

Finally, the participants in the study were asked to indicate why it is most important to carry out the traceability of the food products they consume. In the survey, some options were presented, such as obtaining information about the producer of the product, obtaining information about the type, duration and conditions of the transport of food products for consumption, obtaining information about the period and conditions of storage of these products, food safety or simple curiosity. Each participant was also allowed to indicate another reason for considering traceability important. The results are presented in Table 9.

Table 9. Absolute and relative distribution of the answers obtained on why the consumer considers the traceability process of food products important

Variables	Categories	Absolute Value	Relative Value
		(n)	(%)
Food safety	Yes	112	90.3
	No	12	9.7
	Total	124	100.0
Obtain information on storage period and conditions	Yes	51	41.1
	No	73	58.9
	Total	124	100.0
Get information about the producer	Yes	41	33.1
	No	83	66.9
	Total	124	100.0
Obtain information on the type, duration and conditions of transportation	Yes	40	32.3
	No	84	67.7
	Total	124	100.0
Curiosity	Yes	20	16.1
	No	104	83.9
	Total	124	100.0

Source: Authors' own elaboration

Data in the table indicate that curiosity is not a significant factor driving consumers to consider food traceability. Only 20 participants (16% of the sample) indicated that traceability should be conducted out of curiosity about the product. The vast majority—around 90%—cite food safety as their primary motivation for supporting food traceability. Less than half of the participants provided additional reasons, such as the need for information about storage conditions and duration (about 41%), details about the producer (33%), and information on the type, duration, and conditions of transport (32.3%). In addition to these common reasons, one participant emphasised the importance of knowing the product's origin. At the same time, another mentioned the value of learning about the packaging, its batches, and the chemicals used in production. Another participant highlighted the importance of understanding the "types of fertilisers, nutrients, and pesticides" applied, as these can affect the product's quality and pose health risks to consumers. This

participant also stressed that all such details, including how the products are treated and any chemical or microbiological tests performed, should be clearly labelled, similar to other supermarket products.

When reviewing the literature regarding the consumers' perspective on the traceability of food products, Dopico et al. (2016) realise that in the literature on the subject, consumers associate the term traceability with food safety, the quality of products in the sector, identifying as benefits of the process the possibility of knowing the origin of these products and their control. The origin of a product and its control in the production and distribution chain act as indicators of quality or as signals that give confidence to consumers (Van Rijswijk et al., 2008; Van Rijswijk and Frewer, 2012). Dopico et al. (2016) state that the results of the literature allow us to deduce that consumers associate traceability essentially with food safety, quality and origin. As far as quality is concerned, this

includes both knowledge of the intrinsic characteristics of a product and the possibility of controlling different aspects related to production processes (e.g. sustainability). Additionally, Verveke and Ward (2006) showed that consumers do not seem to show interest in traceability per se. Traceability is a means to know what matters to them - the quality of the product.

Final Considerations

This study provides valuable insights into how Portuguese consumers perceive food traceability systems, particularly regarding their socio-economic impact and the importance of ensuring food safety and transparency. The findings reveal that most consumers view traceability as a critical factor in purchasing decisions, emphasising food safety, product origin, and transportation conditions. However, many consumers are either unaware of or do not fully understand the importance of traceability, highlighting the need for improved consumer education and communication about its benefits. The results from the sample of Portuguese agri-food consumers align with existing literature, showing that many consumers are still not fully informed about food traceability. One in ten participants indicated that their food products' traceability is unimportant. On the other hand, as noted in previous research, consumers tend to associate traceability primarily with food safety, which is the main reason for its implementation. Despite these findings, consumers also recognise the social and economic value of technologies that monitor the temperature at which perishable foods with shorter shelf lives are transported. After food origin, participants identified this as one of the most critical aspects of the traceability process they wish to learn about regarding their food products.

It is important to note that implementing a traceability system incurs costs, which can increase product prices. This is a crucial consideration, as price plays a significant role in the purchasing decisions of Portuguese consumers. According to existing literature, the willingness to pay a higher price due to traceability systems depends on factors such as income level, education, culture, country of residence, and consumer sensitivity to food safety (Dopico et al., 2016; Wu et al., 2012). Future studies on the economic impact of traceability should focus on this issue, particularly by analysing the costs of

implementing traceability technology and comparing them with consumers' willingness to bear the resulting price increase. A thorough cost-benefit analysis should also be part of the decision-making process when considering the adoption of such technology.

While providing valuable preliminary insights, the study's exploratory nature limits the ability to generalise the results or establish causal relationships between variables. The research relies on a relatively small, non-random sample, which may not fully represent the broader Portuguese population. Moreover, the survey was conducted at a specific event, which could introduce bias, as attendees may have a particular interest in agricultural or food-related topics. Future research should address these limitations by expanding the sample size and employing more representative sampling techniques. Additionally, longitudinal studies could track changes in consumer perceptions over time, especially as new technologies are increasingly integrated into traceability systems. Research into the economic feasibility of implementing traceability systems from both consumer and producer perspectives would also be valuable, particularly in understanding consumers' willingness to pay for enhanced traceability.

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