Blockchain based QR-Code: Perception in Consumer Trust and Purchase Intention in Milk Products

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Abstract

The increasing consumer demand for transparency and trust in food supply chains has driven interest in blockchain technology as a tool for enhancing traceability. This study examines the impact of blockchain-enabled QR codes on consumer trust and purchase intention in the Portuguese dairy market, focusing on milk products. Using a mixed-methods approach, the research integrates qualitative in-depth interviews with consumers and a quantitative survey to assess how familiarity with blockchain, ethical concerns, and trust influence willingness to pay extra for milk with blockchain verification. The findings indicate that while blockchain technology enhances perceived transparency, consumer awareness remains limited. Trust in blockchain-enabled QR codes significantly correlates with purchase intention, but price remains a dominant factor. Ethical concerns, particularly regarding food safety and sustainability, positively influence trust but only moderately impact willingness to pay extra. Although blockchain familiarity plays a vital role in increasing trust, its effect on consumer decision-making is weaker than expected. Educational initiatives and pricing strategies are crucial for increasing consumer adoption of blockchain-based food verification.

Keywords: blockchain technology, QR code, consumer trust, purchase intention, food transparency, supply chain traceability, ethical consumption, dairy industry, Portugal.

Título: Código QR baseado em blockchain: Percepção da Confiança do Consumidor e Intenção de Compra em Leite

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Sumário

A crescente procura dos consumidores por transparência e confiança nas cadeias de abastecimento alimentar tem impulsionado o interesse na tecnologia blockchain como ferramenta para melhorar a rastreabilidade. Este estudo analisa o impacto dos códigos QR baseados em blockchain na confiança do consumidor e na intenção de compra no mercado português de lacticínios, com foco nos produtos lácteos. Através de uma abordagem de métodos mistos, a pesquisa combina entrevistas qualitativas em profundidade com consumidores e um questionário quantitativo para avaliar como a familiaridade com blockchain, as preocupações éticas e a confiança influenciam a disposição para pagar por leite com verificação blockchain. Os resultados indicam que, embora a tecnologia blockchain aumente a perceção de transparência, o conhecimento do consumidor sobre o tema ainda é limitado. A confiança nos códigos QR baseados em blockchain tem uma correlação significativa com a intenção de compra, mas o preço continua a ser o fator predominante. As preocupações éticas, especialmente no que diz respeito à segurança alimentar e à sustentabilidade, influenciam positivamente a confiança, mas têm um impacto moderado na disposição para pagar um valor adicional. Embora a familiaridade com blockchain desempenhe um papel no aumento da confiança, o seu efeito na decisão de compra dos consumidores é menos expressivo do que o esperado. Iniciativas educacionais e estratégias de preços são essenciais para aumentar a adoção da verificação alimentar baseada em blockchain.

Palavras-Chave: tecnologia blockchain, código QR, confiança do consumidor, intenção de compra, transparência alimentar, rastreabilidade da cadeia de abastecimento, consumo ético, indústria de lacticínios, Portugal.

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1. Introduction

1.1. Background and Contextualization

Concerns about safety, sustainability, and authenticity of the food eaten have grown in recent years among consumers caused by innumerous food fraud scandals worldwide. (Singh & Sharma, 2022) Blockchain technology has been proposed to improve traceability and transparency in the food sector, since consumers can access this information directly through QR codes, which serve as an interface and improve trust in producers once the information uploaded in the blockchain is immutable. (Wang et al., 2021)

Since businesses worldwide, and particularly in Portugal, are still figuring out how to incorporate this innovation into their supply chains, it is unclear how much the integration of this type of technology affects customer trust, and purchase intention in the Portuguese market. This research attempts to understand the extent to which this integration affects these factors. (Ozkaya et al., 2015)

The category of dairy goods, especially milk products are particularly alarming since the conservation and production processes need to be very meticulously done to ensure food safety norms to provide consumers a product, they can consume without any possibility of food poisoning. (Montgomery et al., 2020)

Customers are particularly concerned about the supply chain process when choosing a product, regarding for example, animal rights, chemicals being used in products, organic and cruelty free production processes. This arises from increased use of technology to perform daily tasks and constant access to information. (Vargas-Bello-Pérez et al. 2017)

1.2. Relevance of the topic

Blockchain technology is a recent innovation, still in the early stages of adoption across industries, with limited academic research on its impact. Its integration in the food sector, particularly in Portugal, remains underexplored, making this study highly relevant.

While blockchain enhances transparency and trust in supply chains, its adoption in the Portuguese market is still minimal, with few companies implementing it. Consumer awareness is also low, highlighting the need for further investigation.

This research contributes with novel insights into how blockchain-enabled QR codes influence consumer trust and purchase decisions in the dairy sector. It provides valuable guidance for businesses looking to leverage blockchain for greater transparency and consumer engagement, addressing a crucial gap in both academic and industry knowledge.

1.2. Problem Statement

The rapid digital transformation in the food industry has led to increased demand for transparency, traceability, and trust in food supply chains. (Wang et al., 2021) Consumers are becoming increasingly aware of ethical, environmental, and safety concerns related to food production and sourcing. Blockchain technology has emerged as a potential solution, offering tamper-proof verification, real-time traceability, and enhanced trust in food labeling. (Dey et al., 2021) However, despite its potential benefits, the adoption of blockchain-enabled QR codes in milk products remains limited, raising concerns about consumer trust, willingness to pay, and the effectiveness of blockchain as a transparency tool.

Existing literature suggests that trust in digital verification systems influences consumer behavior, particularly in industries where fraud, misinformation, and ethical sourcing concerns are prevalent. (Singh & Sharma, 2022) However, research on blockchain adoption in dairy products is limited particularly regarding how consumer familiarity with blockchain technology, ethical considerations, and perceived trustworthiness impact purchasing decisions. Moreover, studies indicate that price sensitivity remains a key barrier to the widespread adoption of blockchain-based verification tools, but the extent to which consumers are willing to pay a premium for milk products featuring blockchain-enabled QR codes is unclear (Menon and Jain, 2024).

This research aims to assess this gap by analyzing how consumer trust, ethical concerns, blockchain familiarity, and price sensitivity influence purchasing decisions for milk products verified through blockchain QR codes.

The research questions that will be examined in this case are:

RQ1: How does consumer familiarity with blockchain technology influence the preference for purchasing milk with a blockchain-enabled QR code, in the Portuguese market in milk consumers?

RQ2: How do ethical concerns about milk products influence the willingness to pay extra for blockchain-enabled milk, in the Portuguese market in milk consumers?

RQ3**:** How does consumer trust in blockchain-enabled QR codes influence their willingness to pay more for milk products among individuals who drink milk and live in Portugal?

RQ4: Does higher trust in blockchain-enabled QR codes lead to a greater willingness to pay more for milk products for individuals who drink milk and live in Portugal?

2. Literature Review

The primary goal of this chapter is to give readers a more thorough understanding of QR Code technology and the features that are integrated within blockchain technology for use in milk products. Enabling readers to obtain more in-depth information about a product's lifecycle, from production to shelf, by incorporating real-time data with QR Code technology.

Furthermore, it will present the latest trends in the food industry along with the modern consumer demands in food industry.

2.1. - Blockchain Technology

Blockchain Technology offers a new way to present information in general to people, since it is decentralized, meaning it’s a digital ledger where all transactions are recorded publicly and not associated with any third party in specify anyone can access it everywhere, allowing for full transparency and traceability of the whole supply chain to consumers, it contains blocks of data that are immutable and that contain a list of transactions. (Dey et al., 2021)

2.1.1 - Blockchain Features

The primary advantage of blockchain technology lies in its unique features, which provide substantial benefits across various applications:

- Blockchain is a decentralized system, it does not require a single central authority or controlling server to communicate, record, update, and store data. Because of this structure, the network is stronger, less vulnerable to manipulation, and able to function without the assistance of centralized organizations (Song, Wang, & Merveille, 2020);

- It records and stores data in a way that makes it completely public and available to all blockchain users. Since they can independently check and audit data and know that the

information, they access is trustworthy and difficult to change, users are more likely to trust this system (Wang et al., 2021);

- The majority of blockchain systems work under an open-source framework, meaning that the source code is freely available, usable, and adaptable for different purposes. Because developers from all around the world can modify and extend blockchain technology to meet a variety of demands;

- Is consensus-based, changes on information stored on the blockchain requires network participants' consent, giving it autonomy. By allowing data to be updated safely and systematically throughout the network, this consensus process gives the system the autonomy it needs to make upgrades in a secure and effective manner;

- Blockchain makes it difficult to change historical records by ensuring that every piece of data is kept permanently. For applications like supply chain monitoring, legal paperwork, and finance where keeping a precise and unchangeable record is critical, this immutability feature is essential (Rapezzi et al., 2024);

- By using distinct blockchain addresses rather than personal identification, blockchain technology offers a certain degree of user anonymity. By enabling users to interact with the blockchain in a secure and anonymous manner, this method improves privacy and boosts system credibility by protecting users' confidential data;

According to Singh and Sharma (2022), transparency high as 90% will be the key trigger to impulse purchase, adding to the fact that global food traceability market is expecting to grow by 2025 to 22.3 billion dollars, so Blockchain technology is a good booster to support the need for a more transparent food market.

2.1.2 - Challenges of implementation

Implementing blockchain technology in the food industries brings its challenges since both the industry and the technology itself are complex.

According to Menon and Jain (2024), the fast-paced growth of the food industry's daily transactions creates technological challenges related to scalability, data management, and efficiency transactions. These challenges may be too complicated to handle in comparison to

traditional systems like Visa, which process millions of transactions every second. Blockchain's dependence on decentralized data storage may also result in privacy concerns and security risks, including attacks and smart contract weaknesses, which could pose serious dangers to supply chain participants.

2.2. - QR Code Technology

QR Code technology was invented in 1994 by Denso Wave, a subsidiary of Toyota, to upgrade scanning and data storage more efficiently in comparison to the traditional barcodes. (Fine & Clark, 2015)

Stands for Quick Response since its goal is to store a lot of data and quickly show it to customers using a 2D matrix code that a smartphone can scan. Businesses use technology to give users information that allows them to access any kind of data quickly and easily, including text, links, photos, websites, and forms. (Soon, 2008)

The features that are incorporated in the QR Code are:

- **Quite zone,** a white margin around the code, to enable readability;
- **Fidding Pattern,** the rectangles on the corners, which represent the detection system;
- **Alignment Pattern,** cored any distortions that may exist;
- **Timing Pattern,** composed by horizontal and vertical lines that combine connect the finding patterns;
- **Cells,** place where the data is stored;

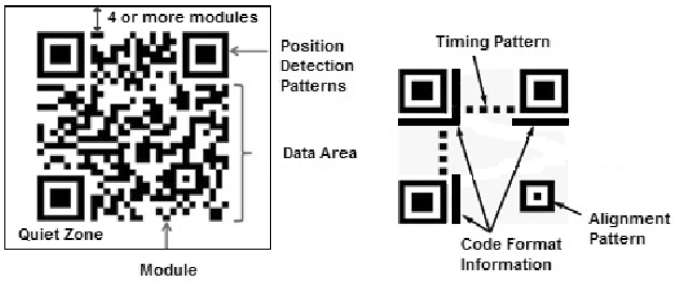

Figure 1- QR Code intrinsic features

(García-Betances & Huerta, 2012)

The ability of QR Code technology to hold a wide range of data, such as images, website links, and alphabetical and numeric data, is one of its advantages. Furthermore, the QR code's shape and color can be altered, and its information storage capacity is greater than that of one-dimensional barcodes. (Ozkaya et al., 2015)

Although QR codes provide quick, easy access to information via mobile devices, they have major benefits for customer interaction, customers no longer have to manually enter URLs, which facilitates rapid access to product details, and other resources. Compared to conventional barcodes, QR codes can store a lot of data and are less expensive to create. (Fine & Clark, 2015)

Additionally, they give marketers the chance to incorporate incentives like sales, competitions, and unique content, all of which increase customer engagement and connection. With the growing popularity of smartphones, QR codes have emerged as a powerful tool for connecting digital and physical goods, assisting companies in increasing consumer convenience, boosting engagement, and creating a customized user experience. (Ozkaya et al., 2015)

2.2.1 - QR Code with decentralized information

Blockchain technology is increasingly being integrated with traditional QR codes, opening a wide range of options for the food business market, including the possibility of boosting consumer trust by giving a transparent and safe means of ensuring product authenticity. (Wang et al., 2021) Provides food products with a unique digital identification making it easier to trace on the supply chain, since it includes batch number and expiration date. In addition, reduces the possibility of food fraud by allowing end-to-end traceability ensuring consumers receive the products as advertised, reducing mislabeling, ingredient adulteration and false documentation. (Singh & Sharma, 2022)

Fraud Category	**Different forms of frauds**	**Supply chain stage as a source**	**Data Captured by IoT and secured by blockchain**
Document Falsification and data manipulation	1. Absence of document 2. Data Manipulation	All stages	Documents and data detail caputred and stored. Documents and data cannot be manipulated and if available, can be easily accessed by consumers and regulating agencies at any point of time by scanning the code on product pack
Misbranding	1. False Claim on origin of product 2. False Claim of organic 3. False Claim of vegetarian and vegan	1. Sourcing of raw material 2. Processing	
Adulteration	1. Addition of unapproved/undeclared ingredient 2. Addition of cheaper ingredient		
Unapproved process	1. Not adhering to food safety norms/to Halal process while claiming to be Halal		

Table 1 - Types of Food Fraud that can be controlled at different stages of food supply chain

(Adapted Table 3 from Singh & Sharma, 2022)

QR Code with decentralized information, differs from traditional ones because the information provided is given in real time allowing consumers to track more efficiently products from farm to shelve, thus each transaction is recorded in an immutable and verifiable manner. (Rejeb et al., 2020) From the producer's point of view it removes trade barriers, automizes processes and increases trust between stakeholders within the supply chain and final consumers. (Contini et al., 2023)

2.2.2 - QR Code Market Implementation Examples

In international and Portuguese market began to emerge a bigger commitment from retailers into providing decentralized information to consumers, to stand out from competitors by using a strategy more focused on the consumer point of view allowing them to view data in real time. (Singh & Sharma, 2022)

Bellow there will be present products and services that are created and implemented in companies worldwide, some created by the retailers itself others by third parties.

2.2.2.1 - International Market

Worldwide there has been a spread of services offering retailers the ability to place blockchain technology on their products specially QR codes paired with blockchain technology and smart contracts allowing a broader view of the network involved in the production of products enhancing accountability across supply chain and building a consumer trust in retailers by providing product tracing.

Product/Service	**Distribution Network Design**	**Purpose**	**Method/Tools used for traceability**
Food Supply Chain (Pork, Mango)	Retail Storage customer pick-up	Better customer experience	IoT sensors, QR Code
Food Supply Chain (Halal food item)	Retail Storage customer pick-up	Higher transparency and assurance of halal compliance	IoT devices, smart contract, QR Code
Food Supply Chain (Agro-food products)	Retail Storage customer pick-up	Prevent food safety hazards	Smart Contracts, Smart Tags, IoT devices
Agro-food (Soybean)	Retail Storage customer pick-up	Better customer experience throught ability to trace origin of product	Smart Contract, IoT

Table 2 - Summary of blockchain-based traceability solutions

(Adapted Table 2 from Sunny et al., 2020)

These types of solutions benefit retailers in terms of cost saving by allowing them to better manage their food supply into being wasted due to recalls of contamination and quality standards. If a product recall is not done at the appropriate time, it can affect consumer trust since it can result in foodborne illness by not meeting the minimum standards.

Year	**IT Solution Provider**	**Companies using blockchain technology program**	**Program Objetive**
2017	IBM	Dole, Driscoll's, Golden State Foods, Kroger, McCormick & Co., McLane Company, Nestlé, Tyson Foods, Unilever, and Walmart	Intention of streghtening consumer confidence in the global food supply
2019	IBM	Nestlé and Carrefour	Track supply chain of Mousline brand from source to consurmers journey
2019	OpenSc	WWF-Australia and BCG Digital Ventures	Track products they produce, as well as consumers being able to view origns
2019	OpenSc	Nestlé	Track milk from farm to producers to firm's factories and warehouses
2019	E&Y	E&Y	Help consumers across Asia determine the quality, provenance, and authenticity of importated european wine

Table 3 - Different blockchain technology-based programs currently run by some of the food industries

(Adapted Table 4 from Sunny et al., 2020)

2.2.2.2 - Portuguese Market

In the Portuguese market this technology is starting to emerge at a slow pace, displaying a few companies such as Auchan that use it in products like lettuce, melon and watermelon in a special line called "Vida Auchan" where people have access to blockchain sourced information (Ife, 2020).

Nestle is integrating in their coffee brand SICAL blockchain technology allowing consumers to verify the origin of their coffee from the moment it is produced to the moment it is in the cup. (Agroportal, 2022)

Vera Cruz almonds emerged in a project called almonds with identity to assure consumers can track the whole production process invested in merging blockchain technology into their operations. (De Negócios, 2022)

Despite very few companies started introducing blockchain technology in the Portuguese food industry market, there is still a lot to explore once the companies in this industry haven't started to fully implement blockchain-enabled QR Codes in their production process, as well as the impacts and consequences of the integration of technology on the consumer in this market are unknown.

2.3. - Consumer Perspective

2.3.1. - Purchase Intention

Purchase Intention is a crucial concept to understand consumer behavior, is defined by various authors as the predisposition to buy a specific product or service in the future, it is considered a pre-defined decision since the consumer has conscious about his preferences. Studies show that factors like product quality, perceived value and price perception if seen in a positive way leads to a stronger sense of purchase decision. (Chang & Wildt, 1994).

The increasing in the usage of smartphones by consumers on performing day-to-day activities, like checking information, purchase items, paying for products, is showcasing in businesses specially in the food industry, as the growth for ways to access information and to communicate the product is expanding at a fast pace leading to smart packaging approaches with QR Code technology incorporate enabling a quicker and easier way for consumers to be informed about they are buying. (Soon, 2008)

2.3.2. - Impacts on Consumer Trust: Food Fraud

Consumer trust, which is described as a consumer's belief in the dependability, honesty, and competence of a product or brand, is a significant factor in the decision-making process. Therefore, brands must recognize the significance of keeping their word and considering the interests of their customers. (Chen & Dhillon, 2003)

Due to high-profile food scandals that misled customers about product contents and even caused health problems, consumer trust in the food sector has drastically decreased in recent years. The fact that a substantial portion of food supply chain data is stored in centralized databases contributes significantly to this problem. Companies and its stakeholders have influence over these databases, which gives them the ability to alter or show information in a chosen manner.

Food fraud registered in E.U. food network divides those scandals into three categories:

- **Mislabeling**, that's when products sold with incorrect information on purpose to deceive consumers;
- **False documentation,** meaning product information documents are missing or the data on those is manipulated;
- **Improper ingredients,** placing ingredients, replace them or remove them for profit.

Year	Country	Food fraud category	Example
1981	Spain	Mislabeling	"Rapeseed oil" fraud intended for industrial use was sold as olive oil
1999	Belgium	Inapproved manufacturing process	Dioxin came in food chain via contamined animal fat used in animal feeds
2008	China	Addition of unapproved process	Milk Adulteration with melanine resulting in more than 50,000 sick babies and 6 fatalities
2019	Italy	Document Absent	Italian Tomate were sold sold as Piennolo (an Italian PDO) that lacked the right certificates to prove their geographic origin
2019	Netherlands	Mislabeling	Selling eggs contamined with fipronil and with a false claim that the eggs originated from a farm that produced "free range" eggs
2020	Italy	Addition of unapproved ingredient and Mislaleing	Low-cost wine was sold as a quality product for a higher price, in some cases with claim of being organic

Table 4 - Food Fraud in different categories of claims

(Adapted from Singh & Sharma, 2022)

Milk products dairy and plant-based were chosen to be the product to test in this study since it has been a product that in past thirty years has been increasing the consumption due to their nutritional benefits. Since it is a product that needs a meticulous care regarding the process from farm to shelve, there is an extreme need for a supply chain that is transparent and that provides authenticity to its consumers. (Montgomery et al., 2020)

During the production process various sources of contamination may arise (biological, chemical, or physical) representing a significant risk to consumers due to its toxicity.

Year	Contamination	Country of Origin	Commodity	Issue
2015	Campylobacter	United States	Milk	Warning released in relation to the consumption of raw milk in California. 6 reported ill due to the consumption of raw milk.
2018	Skimed milk powder and sweet oil	India	Milk	Fake milk being produced and sold, from combining skimmed milk powder and sweet oil.
2018	Ghee, urea, and powder	Pakistan	Milk	Milk adulterated with Ghee, urea, and powder milk

Table 5 - Summary of safety and fraud issues relating to milk products found in grey literature from 2015 to 2019

(Adapted from Table 6 Montgomery et al., 2020*)*

2.3.3. - Ethical Consumer Choice: Animal Cruelty and the search for information

Concerns about animal cruelty these days have a strong influence on some consumers' decision-making processes when shopping for food products, particularly in how individuals seek additional information besides the one provided in the packaging. Therefore, it is important for consumers who demand ethically produced animal-based products that these align with their values, and if so, they will be leaner to buy that product. (Contini et al., 2023)

According to Cembalo et al. (2016), consumers who have as a core principle animal welfare prioritize products with certifications or labels that ensure proper treatment of animals, as for example, organic, free-range, animal welfare certified, by seeing these certifications associated with the products when searching actively for information consumers create a bigger trust with the brands.

The primary source of information that is scanned when looking for this type of information is product labeling since is seen as a valuable source of information when seeking for transparency about animal production practices, specifically third-party certifications. (Vargas-Bello-Pérez et al. 2017)

According to Hölker et al. (2019), animal-ethical values act as domain-specific values that strongly predict consumer behavior. These values influence the level of effort consumers are

willing to invest in researching products. For instance, individuals with stronger ethical convictions may avoid products from intensive farming systems entirely and actively seek alternatives that align with their beliefs. The same study links these values to broader concerns, such as sustainability and environmental impact. This connection often leads ethical consumers to investigate not only animal welfare but also the environmental footprint of the products they purchase.

While ethical consumers are willing to seek information, they often face barriers such as information overload or the lack of availability of reliable data. while consumers are becoming more aware of animal welfare, the availability of detailed and trustworthy information remains inconsistent, making it harder for them to make informed decisions. (Cembalo et al., 2016).

2.4. - Food Industry

Food manufacturers must prioritize transparency by developing products and processes that meet future consumer needs and provide authentic, accessible information about their products to build and maintain consumer trust. This is because the food industry supply chain is complicated, with many stakeholders and intermediate processes where information can easily be lost, resulting in countless false claims from packaged food companies. (Singh & Sharma, 2022)

2.4.1. - Future Market Tendencies

Consumer trends are expected to be focused on sustainability, wellbeing, value for money, technology, personalization, and rich experiences over the next decade. This change in the food and beverage sector indicates a transition away from an individualistic "me" orientation and toward a collective "us," as customers' concerns about their own health and the health of the world grow. Mass-market goods will continue to be valuable, but consumers will want more specialized options.

According to Mintel Group Ltd. (2019), companies that put environmental and population health first will dominate the market. Customers are becoming more open to science-based solutions like lab-grown foods, organic produce, and vertical farming, and they are demonstrating a willingness to provide personal information for highly customized products that promote mental as well as physical health. In addition to looking for ingredient lists, today's customers now demand comprehensive information on allergens, side effects, quality standards, and how to store products. They frequently choose companies that meet up to these expectations and avoid those that do not.

With the raise of future trends emerging such as sustainability, health, wellness, and transparency, blockchain technology has brought a big advantage to the market allowing bigger transparency at low transaction costs since data upload in that type of network is not easy to manipulate. This implementation of blockchain technology paired with QR Code allows a sense of empowerment to consumers giving them the possibility to check claims and prevent the purchase of fraud products. (Rapezzi et al., 2024)

By the analysis made through the literature review the following hypotheses emerges:

H1: Consumers who are more familiar with blockchain technology will have a bigger purchase intention to buy milk with a blockchain-enabled QR code.

H2: Consumers who have higher ethical concerns regarding milk production will be more willing to pay extra for a blockchain-enabled milk product.

H3: The integration of blockchain technology in QR codes increases consumer trust in milk products, with higher trust among consumers with food restrictions.

H4: Consumers with higher trust in blockchain-enabled QR codes will have a greater willingness to pay extra for milk products with blockchain verification.

3. Methodology and Data Collection

The aim of this chapter is to further investigate the main findings obtained in the literature review, to support the hypothesis and research questions that emerge from the top journals and articles with data. Methods used for analysis and data collection consists in a qualitative (in-depth interviews) and quantitative (online survey) approach, aiming to explain the different variables, as well as, evaluating the impacts of the use of QR Code with decentralized information in consumer trust, purchase intentions, products authenticity perception, searching for more information.

3.1. Conceptual Framework

Based on the hypothesis a conceptual model is suggested, it is hypothesized that blockchain-enabled QR Codes influence consumer perceptions, were consumer trust plays a significant role as a mediator in determining the purchase behavior. Factors like familiarity with blockchain, ethical concerns and food restrictions influence how much consumers trust the blockchain technology.

Additionally, is hypothesized that higher trust leads to increased willingness to buy milk products with blockchain verification.

There are 3 moderating roles the familiarity with blockchain were prior exposure to blockchain technology can increase trust, consumers with dietary/food restrictions can have higher or lower trust levels depending on transparency expectations, and consumers who prioritize food ethics and sustainability may be more likely to trust and purchase enabled blockchain QR code milk products.

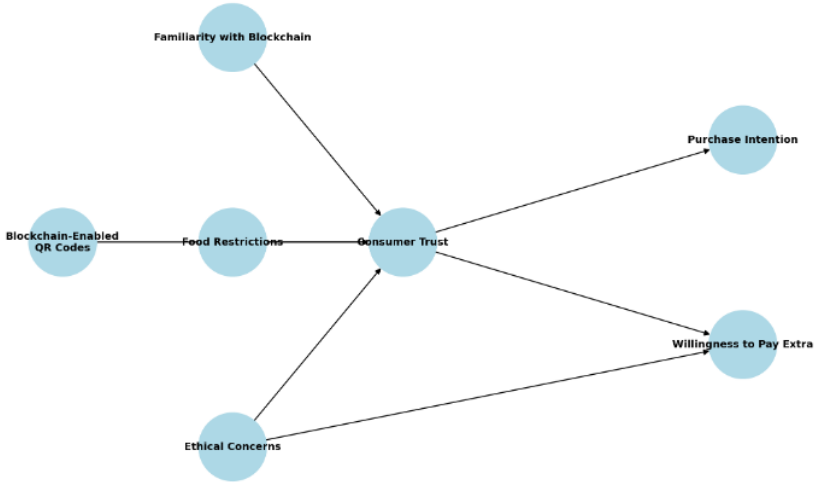

Figure 2 - Conceptual Framework

3.2. Qualitative Method: In-Depth Interviews

3.2.1. Research Design

In-depth interviews are a qualitative research method involving one-on-one conversations that search in depth for interviews experiences, beliefs, and motivations, in this case towards the consumption of milk and the importance given to the transparency of the supply chain. The findings of this type of method are more detailed since researchers can explore with a more flexible and adaptable approach, enabling to obtain deeper insights (Roller, 2015).

The goal of this interviews was to obtain a bigger understanding of the each research question, what type of information is more important for consumers when they are choosing a package of milk, their consumption patterns, if they had knowledge of QR Code/or Blockchain Technology and if so in which area.

An interview script was designed to provide guidance to the interviewees and guarantee that the information needed was collected, it was divided in 7 sections:

1. **Presentation of the study and of the interviewees:** purpose of the interview, explanation of the difference between QR Codes, personal information about respondent;
2. **Psychographics:** milk consumption, frequency of purchase, dietary restrictions;
3. **Initial Thoughts on QR Code and Blockchain:** familiarity with enabled-blockchain technology in general products and in milk products;
4. **H3 related questions:** elements that make people trust information provided by QR codes, if they think the information provided will affect their trust levels;
5. **H1 related questions:** factors influencing purchase decision for food products, willingness to buy an enabled blockchain QR code vs a traditional QR Code;
6. **H4 related questions:** willigness to pay extra for an enabled blockchain QR Code;
7. **H2 related questions:** perception about if product authenticity related to ethical concerns (information about production, animal welfare, etc) will increase the trust in the product being bought if it had enabled blockchain QR Code technology;

Despite this structure, it gave the possibility of interviewees answering naturally, and in some cases extra questions emerge from topics discussed during the conversations.

3.2.2. Interviews Data Collection

A total of 10 people were interwed, the participants age ranged from 22 to 38 years old to obtain different perspectives from different generations.

16 open-ended questions were used in non-standard, semi-structured in-depth interviews based on the study questions, hypothesis, and original findings to gather qualitative data. A script was designed to guide the interviews divided in 7 sections composed by Zoom was used for one-on-one interviews, which lasted ten to fifteen minutes on average. (Appendix 7.1.1)

3.3. Quantitative Method: Survey

3.2.1. Research Design

A survey is a research method used to collect data from a specific population through structured questionnaires, aiming to gather information. Surveys are highly versatile, allowing researchers to reach large audiences quickly and cost-effectively, making them ideal for collecting quantitative data (Groves et al., 2009).

The survey created has as construction base the previous insights gathered from the literature review an in-depth interview done and has as main purpose to validate the hypothesis to be able

to answer the research questions. It has available in English and Portuguese for participants choose the preferred language that they feel more comfortable with.

3.2.1.1. Indicators and Variables

The constructs used served to measure the different variables in this study: consumer trust, purchase intention, perceived product authenticity, preference for blockchain enable QR codes, and information seeking behavior. In this study the pre-existing scales used to create the constructs were altered in terms of the wording used to fit into the purpose of the study, a description of each one is provided above:

Construct	Literature	Adapted Questions	Measure
Consumer Trust on enabled blockchain QR Codes	(Lau & Lee, 1999)	I am more likely to trust milk brands that use blockchain technology to ensure transparency. I think that the milk with Blockchain QR Code can be trusted for its transparency and reliability. In general, I can rely on enabled blockchain QR Codes to provide transparency, and authentic information about the milk supply chain. In general, I think that enabled blockchain QR Code can be trusted to assure that milk is of high quality.	7-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree)
Purchase Intention towards enabled blockchain QR Codes	(Barber et al, 2020) + (Zhou et al., 2018) + (Everard & Galletta, 2005)	I would consider purchasing a milk product with blockchain enabled technology I intend to try to scan a milk product with enabled blockchain technology I plan on buying a milk product with enabled blockchain technology	7-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree)

		I am interested in finding more about information about the milk product via the enabled QR blockchain technology If I had the chance, I would buy a milk with enabled QR Code technology. In the future, I would like to buy a milk with enabled QR Code technology.	
Ethical Concerns associated with enabled blockchain QR Codes	(Laroche et al., 2001)	It is important to me to find information to buy milk products with sustainability and animal welfare certifications. It is important to me to find ways to check food fraud and product claims in milk products How milk production may affect the environment and animals' welfare is important to me	7-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree)

Table 6 - Measures Constructs Building Scales

3.3.3. Survey Resume and Data Collection

The online survey was conducted in the Qualitrics platform, and was sent to collect responses via whatsapp, instagram, and e-mail, taking 5 minutes to be completed. The collection phase for responses lasted from 4th to March 8th with a total of 133 responses where after excluding respondents that do not live in Portugal 6 were removed remaining 127, after it was also excluded people did not drink milk removing 24 people and remaining for analysis 103 respondents. (Appendix 7.2.1)

The survey is divided into 6 sections:

- **Screening Questions (4 questions) -** 2 main questions to divide respondents and have a better output in terms of results, one to exclude people who do not live in Portugal since the aim of the study is to assess the Portuguese market. Other question to exclude

people who do not drink milk from answering related to consumption patterns (frequency of buying milk and consumption behaviors);

- **Familiarity with QR Codes & Blockchain (3 questions) -** used to assess the usage of QR codes when shopping, and the degree of familiarity with blockchain technology itself and paired with QR codes;
- **Experimental Scenario/Purchase Intention (4 questions/2 descriptives) -** used to assess the traceability and understanding of the differences between a centralized and decentralized QR Code. The 2 descriptive questions serve to prepare the responder with the information needed about these types of QR Codes paired with 2 key features that attract consumers, to assess the purchase intentions with different possibilities of price (same price/lower price/higher price);
- **Ethical concerns (1 question with statements)-** to assess the possible correlation between search for information and food restrictions;
- **Consumer trust (1 question with statements)-** to assess the trustworthiness of enable QR Code blockchain technology, as well as what the innovation can provide itseflf in terms of transparency, reliability, and perceived authentic information;
- **Demographics (7 questions)-** used to characterize the sample for descriptive purposes, in addition a question about food restrictions were placed to assess later if people who have limitations in what they in a regular basis search for more information when choosing a product.

3.3.4. Survey Demographics

Most participants fell within the 18-24 age group (42,7%), followed by those aged 25-34 (27,2%). The remaining respondents were distributed across the age categories 35-44 (11,7%), 45-54 (12,6%), and a small percentage (1%) were aged 55 or older (Appendix 7.2.3-)

52,4% of respondents identified as female, 45,6% as male, while 1,0% identified as non-binary/other, and an additional 1,0% preferred not to disclose their gender. (Appendix 7.2.3)

Most respondents were Portuguese (94,2%), while smaller proportions of the sample identified as German (3,8%), French (1,9%), and Italian (1%). (Appendix 7.2.3)

The occupational distribution is visualized in Figure 3 (appendix 4). The largest proportion of respondents were employed (53,4%), followed by students (20,4%), and working students (14,6%). Additionally, 7,8% were independent workers, while only 2,9% were unemployed and 1% were retired. (Appendix 7.2.3)

The most common income category was 1,000€ to 1,499€ (35,9%), followed by 19,4% of respondents either did not receive a direct income or by 18,4% that earned between 1,500€ and 1,999€. Additionally, 15,5% of respondents reported earning more than 2,000€ per month, and 9,7% had an income between 500€ and 999€. (Appendix 4, Figure 4 – Monthly gross income distribution). (Appendix 7.2.3).

Majority of respondents had either a bachelor's degree (42,7%) or had completed master's degree (42,7%). A smaller proportion (14,6%) had completed high school. (Appendix 4, Figure 5 – Lecel of Education Distribution).

4. Results

4.1. Interview Results

10 people were interviewed aged from 22 to 38 years old, 5 females and 5 males, all living in Portugal. From the 10 interviewees 5 had no food restrictions, 2 were gluten or dairy intolerant, and 3 did not eat meat due to concerns about animal cruelty.

The integration of blockchain technology in QR codes significantly impacts consumer trust by enhancing transparency and traceability. Participants expressed trust in decentralized systems due to their perceived impartiality and resistance to data tampering. The ability to verify production details such as temperature, origin, and supply chain processes increases consumer confidence. For instance, some highlighted that decentralized QR codes assure consumers of data authenticity, boosting trust in brands. This aligns with the hypothesis that blockchain-enabled QR codes enhance consumer trust.

However, skepticism remains among some participants who question whether companies would fully disclose sensitive information. While trust improves with transparency, trustworthiness depends on the consistency and completeness of the shared data.

Decentralized QR codes positively influence purchase intentions, particularly for consumers prioritizing food safety and ethical sourcing. It was emphasized the role of such technology in reducing risks associated with food allergies and past food poisoning experiences. Many interviewees were inclined to choose products with decentralized information, even if priced slightly higher, provided the additional cost remained reasonable.

Nevertheless, cost sensitivity plays a critical role in decision-making. For example, a participant would prefer decentralized products and stated that he would not pay significantly more if similar alternatives existed.

The presence of blockchain-enabled QR codes enhances perceptions of product authenticity, further influencing willingness to pay. Respondents valued the verifiable and immutable nature of blockchain data, which reassures them about product quality, origin, and adherence to EU regulations. Transparency empowers consumers, making their purchase decisions more informed and reliable.

However, some participants pointed out that brand reputation often supersedes blockchain features in influencing purchase decisions. Familiar brands with established trustworthiness may gain less incremental value from QR codes, whereas emerging brands can leverage this technology to build credibility.

Participants consistently emphasized the importance of accessible and relevant information, such as certifications, nutritional content, and sourcing details. Key decision-making factors include price, quality, and ethical considerations (e.g., local production or sustainability).

Barriers to adoption include price sensitivity and varying levels of technological awareness. While most participants appreciated the potential benefits, relied on traditional trust mechanisms like legal compliance and third-party certifications over modern technologies.

4.2. Survey Results

4.2.1. Sample Characterization

Food/Dietary Restrictions

Most participants (66 respondents) reported having no dietary restrictions. Among those who did, the most common restriction was lactose intolerance (18 respondents). Additionally, 7 respondents each reported being vegetarian, gluten intolerant, or pescatarian (only eating fish, no meat). A smaller number of respondents followed a meat-only diet (3 respondents) or identified as vegan (2 respondents). There is a dietary diversity within the sample, with a considerable proportion of respondents experiencing lactose intolerance (18), which could influence their preferences for dairy products, including those featuring blockchain-enabled QR codes for transparency in production.

To better understand the impact of food restrictions towards enabled blockchain QR Code it was computed a new variable called Food Restrictions with 2 levels:

- **1 = No Food/Dietary restrictions,** composed by no;
- **2 = Yes Food/Dietary restrictions,** composed by lactose intolerant, gluten intolerant, vegan, vegetarian, only eats fish, only eats meat;

Milk Purchase Behavior

The most common milk purchase frequency is weekly, reported by 31.1% (n = 32) of respondents. Additionally, 21.4% (n = 22) purchase milk every two weeks, while 22.3% (n = 23) buy milk monthly. A smaller percentage of respondents purchase milk less often than monthly (12.6%), while only 4.9% (n = 5) purchase milk daily, and 7.8% (n = 8) purchase it 2–3 times per week. Meaning, most respondents tend to buy milk weekly or biweekly, which indicates a regular consumption pattern.

Knowledge of QR Code technology and Familiarity with Blockchain Technology

35.9% of respondents reported being "Not familiar" with blockchain technology, meaning that more than one-third of the sample lacks fundamental knowledge of QR codes and blockchain. 19.4% indicated being "Slightly familiar", while 13.6% stated they are "Somewhat familiar", representing a moderate level of awareness among some consumers. A combined 25.3% of respondents claimed to be either "Moderately familiar" (13.6%) or "Very familiar" (11.7%), demonstrating a slightly higher awareness of these technologies. Only 1% described themselves as "Extremely familiar", highlighting that very few consumers have a deep understanding of blockchain and QR code technology.

Indicating that while a small segment of consumers has some degree of familiarity with QR codes and blockchain technology, the majority still exhibit limited awareness or knowledge in this area.

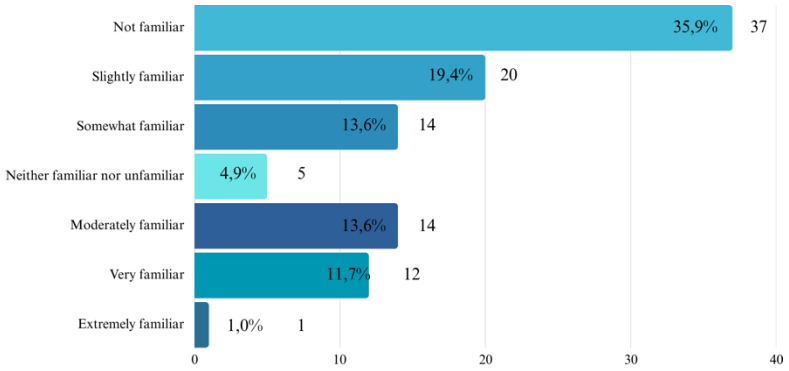

Figure 3 - Familiarity with blockchain technology Descriptives

80.6% of respondents answered "No", meaning that most participants have never scanned a QR code on a milk product. Only 19.4% of respondents answered "Yes", indicating that less than one-fifth of consumers have actively engaged with QR codes on milk packaging. Highlight a major gap between the availability of QR codes on milk products and actual consumer usage.

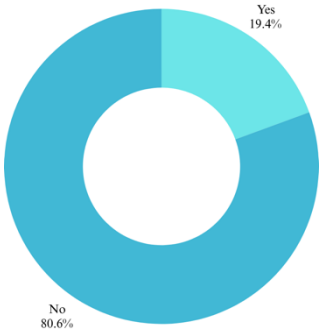

Figure 4 - Familiarity with QR Code technology Descriptives

Blockchain differences in price

67% of respondents preferred blockchain-enabled QR code milk, whereas 33% preferred traditional QR code milk. Suggesting that, when price is not a differentiating factor, most consumers see added value in blockchain technology for milk products.

Type of QR Code	Frequencie (N)	Percentage (%)
Milk with traditional QR Code	34	33,0%
Milk with enabled blockchain QR Code	68	67,0%

Table 7 – Price of both milks is equal Descriptives

75.7% of respondents preferred blockchain-enabled QR code milk, while only 24.3% opted for traditional QR code milk. This result indicates that if blockchain-enabled milk is the cheaper option, it becomes significantly more attractive to consumers. However, rather than reflecting a stronger preference for blockchain technology, this trend suggests that price plays a dominant role in consumer decision-making.

Type of QR Code	Frequencie (N)	Percentage (%)
Milk with traditional QR Code	25	24,3%
Milk with enabled blockchain QR Code	78	75,7%

Table 7 - Price of Milk with traditional QR Code being more expensive Descriptives

Some consumers are open to paying a slightly higher price for blockchain-enabled milk, the majority (55.3%) are unwilling to pay extra at all. Only 12.6% of respondents are willing to pay more than 5% extra, highlighting that the perceived value of blockchain in milk traceability does not currently justify a significant price increase for most consumers.

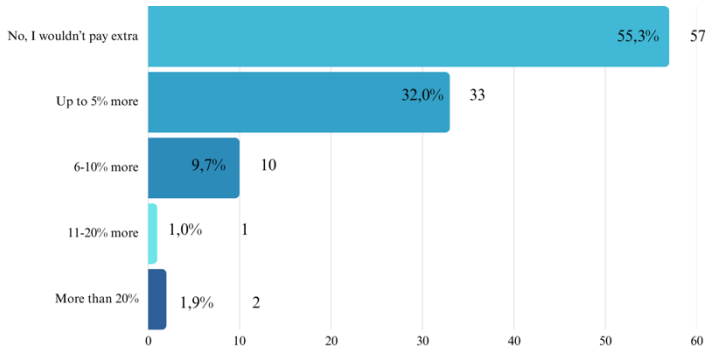

Figure 5 - Willingness to pay extra for blockchain milk Descriptives

Blockchain technology alone is not sufficient to drive higher consumer willingness to pay. Instead, pricing remains a critical factor, with most consumers favoring the more affordable option regardless of blockchain integration. While blockchain-enabled QR codes might provide added transparency, their perceived value does not yet justify a significant price increase.

4.2.2. Reliability and Correlation Analysis

Cronbach' alpha is used to check the internal consistency of contructs made by a multiple item scale (Saunders et al, 2009). Quality for purchase intention and consumer trust is excellent, and quality is good for ethical concerns.

Construct	Number of Items	Cronbach's alpha	Quality

Purchase Intention (P1)	6	0,944	Excellent
Ethical Concerns (EC1)	3	0,888	Good
Consumer Trust (CT1)	4	0,945	Excellent

Table 8 - Cronbach's alpha of Contructs

After the reliability of the scales is assured, it allows the creation of the constructs Consumer Trust, Purchase Intention and Ethical Concerns by computing the mean of answers in the items used for each scale.

Descriptive of the Construct Variables Created							
Constructs/ Variables	**N**	**Minimum**	**Maximum**	**Mean**	**Std.Deviation**	**Skewenss**	**Kurtosis**
Purchase Intention	103	1.17	7.00	5.016	1.298	-0.990	0.285
Ethical Concerns	103	2.00	7.00	5.602	1.173	-1.146	1.109
Consumer Trust	103	1.00	7.00	5.260	1.190	-0.845	0.798
Food Restricition	103	0.00	1.00	0.476	0.582	0.099	-2.030
Willingness to pay extra	103	1.00	5.00	1.620	0.853	1.689	3.544

Table 9 - Construct/Variables Created Descriptives

To examine the relationships between the key variables Familiarity Level, Willingness to Pay Extra, Food Restriction, Consumer Trust, Ethical Concerns, and Purchase Intention a correlation matrix was performed (Appendix 7.2.3 – Table 10 Matrix Correlation).

The results indicate a strong, significant positive correlation between consumer trust and purchase intention ($r = 0.638$, $p < 0.001$). Consumers who trust milk products more are significantly more likely to have a higher intention to purchase.

Ethical concerns are moderately and significantly correlated with purchase intention ($r = 0.323$, $p < 0.001$) and consumer trust ($r = 0.424$, $p < 0.001$). This suggests that individuals who place greater importance on ethical considerations, such as sustainability, fair trade, and food transparency, are more likely to purchase milk products and have higher trust in them.

A moderate positive correlation was observed between willingness to pay more for a milk product with a blockchain-enabled QR code and purchase intention ($r = 0.372$, $p < 0.001$). This suggests that consumers who are willing to pay a premium for blockchain-enabled milk are more likely to purchase the product.

A strong and significant negative correlation was found between blockchain QR code preference and purchase intention ($r = -0.540$, $p < 0.001$). This result indicates that consumers who prefer blockchain-enabled QR code milk are less likely to purchase it. Additionally, consumer trust is negatively associated with blockchain QR code preference ($r = -0.501$, $p < 0.001$), suggesting that consumers who prefer blockchain QR codes trust the product less.

A weak but significant positive correlation was observed between ethical concerns and willingness to pay for blockchain QR code milk ($r = 0.243$, $p = 0.013$). While ethical concerns play a role in consumers' willingness to pay more for such products, the strength of this relationship is low.

The findings highlight several important relationships between variables consumer trust is the strongest predictor of purchase intention, reinforcing the importance of building trust in milk products, ethical concerns contribute to higher trust and purchase intention, but their influence on blockchain-related preferences remains limited.

4.3. Hypothesis Testing

H1: Consumers who are more familiar with blockchain technology will have a bigger purchase intention to buy milk with a blockchain-enabled QR code.

It was performed a Linear Regression where the $R^2 = 0.070$ meaning that 7,0% of the variance in purchase intention is explained by blockchain familiarity. P=0.007 since p<0.005 meaning the model is significant and that blockchain familiarity is a significant predictor of purchase intention. The Beta = 0.264, so blockchain familiarity has a weak-to-moderate impact on purchase intention. (Appendix 7.2.3 – H1 Testing Linear Regression Output)

So H1 is supported, consumers who are more familiar with blockchain technology are more likely to choose blockchain-enabled QR code milk.

H2: Consumers who have higher ethical concerns regarding milk production will be more willing to pay extra for a blockchain-enabled milk product.

It was performed a spearman's rank correlation, and an ordinal regression was the correlation coefficient was p=0.243 indicating a weak positive correlation between ethical concerns and willingness to pay extra. On the other hand, p-value (sig) = 0.013 (<0.05) suggesting that the relationship is statistically significant, meaning individuals with higher ethical concerns tend to

be more willing to pay extra for an enabled blockchain QR Code. (Appendix 7.2.3 – H2 Testing Spearman's Rank Correlation and Ordinal Regression Output).

H2 is supported, so people with higher ethical concerns are willing to pay extra for blockchain milk.

H3: The integration of blockchain technology in QR codes increases consumer trust in milk products, with higher trust among consumers with food restrictions.

Independent Sample T-test was conducted the mean trust score is higher for consumers with no food (5.49) than for those who have food restrictions (5.01), that neglects the original hypothesis. By checking the Levene's test for equality of variances $p = 0.236$ (> 0.05) so we failed to reject the null hypothesis of equal variances. There is a statistically significant difference in consumer trust between those with and without food restrictions.

The t-test results indicate that $p(sig)=0.042$ (<0.05), so there is a statistically significant difference in consumer trust between those with and without food restrictions, were the mean differences = 0.476. The cohen's $d=1.171$ indicating a large effect size so the difference between groups is meaningful. (Appendix 7.2.3 – H3 Testing Independent Sample T-test Output).

H3 is not supported, and the result state the opposite.

H4: Consumers with higher trust in blockchain-enabled QR codes will have a greater willingness to pay extra for milk products with blockchain verification.

A linear regression was performed to check if there is a relation between variables $R=0.277$ shows a weak positive correlation between trust and willingness to pay. $p(sig)=0.005$ (<0.05), meaning the model is statically significant, and that each time trust increases the willingness to pay will also increase. (Appendix 7.2.3 – H4 Testing Linear Regression Output)

Beta=0.227 showing that trust has a weak to moderate positive effect. Confidence interval is between (0.062 and 0.334) confirming the significance of trust.

H4 is supported meaning higher trust in blockchain-enabled QR Codes significantly increases willingness to pay extra for milk products.

5. Discussion

5.1. Results

***RQ1:* How does consumer familiarity with blockchain technology influence the preference for purchasing milk with a blockchain-enabled QR code?**

The results support the hypothesis that familiarity with blockchain technology influences purchase decisions for milk with blockchain-enabled QR codes. The literature review highlights that blockchain technology is increasingly used in the food industry to improve traceability, transparency, and consumer trust (Singh & Sharma, 2022). However, studies indicate that consumer awareness and understanding of blockchain technology remain limited, which can be a barrier to adoption.

The qualitative interviews showed that while most participants had no prior knowledge of blockchain-enabled QR codes in food products, they expressed interest in the concept once its benefits were explained. Some participants emphasized that their lack of familiarity made them hesitant to trust the technology, aligning with previous research on consumer resistance to new digital verification tools.

The quantitative analysis confirmed a statistically significant but weak positive correlation ($r = 0.264$, $p = 0.007$) between blockchain familiarity and purchase intention. This suggests that consumers with greater awareness of blockchain are more likely to prefer blockchain-enabled QR code milk. However, only 25.3% of respondents reported being moderately to very familiar with blockchain, indicating that a lack of consumer education remains a key challenge in this market.

Thus, while blockchain familiarity positively influences consumer preference, the current low levels of awareness highlight the need for greater consumer education efforts by brands and retailers.

***RQ2:* How do ethical concerns about milk products influence the willingness to pay extra for blockchain-enabled milk?**

Ethical concerns were identified as a key factor in willingness to pay, but their influence is moderate rather than dominant. The literature review suggests that consumers who prioritize ethical considerations—such as animal welfare, sustainability, and transparency—are more

likely to trust food products verified through blockchain (Cembalo et al., 2016; Vargas-Bello-Pérez et al., 2017).

The qualitative interviews reinforced this finding. Participants who expressed strong ethical concerns (such as dietary restrictions due to lactose intolerance or veganism) were more inclined to trust blockchain-enabled QR codes, as these provide verified, immutable data about product origin and production practices. However, some interviewees remained skeptical, arguing that corporate transparency is still controlled by brands despite blockchain's immutability.

The quantitative analysis showed a weak but significant positive correlation ($r = 0.243$, $p = 0.013$) between ethical concerns and willingness to pay more for blockchain-enabled QR code milk. Consumers with higher ethical concerns were slightly more willing to pay extra, but the strength of the relationship was not as high as expected. This suggests that while ethics play a role, price remains the dominant factor in purchase decisions.

Overall, ethical concerns do influence willingness to pay, but the perceived cost-benefit ratio remains a key barrier to adoption.

***RQ3*: How does consumer trust in blockchain-enabled QR codes influence their willingness to pay more for milk products among individuals living in Portugal?**

The findings confirm that consumer trust in blockchain-enabled QR codes plays a crucial role in willingness to pay extra. The literature review emphasizes that trust is a fundamental driver of consumer purchase behavior in food products, particularly when modern technologies are introduced (Lassoued & Hobbs, 2015). Studies indicate that consumers trust decentralized, tamper-proof verification systems more than traditional corporate claims, supporting the potential of blockchain-based QR codes.

The qualitative interviews revealed mixed perceptions of trust. Many participants viewed blockchain-enabled QR codes as a trust-enhancing tool, particularly for tracking food safety, ethical certifications, and supply chain transparency. However, some remained skeptical about whether companies would fully disclose all relevant data. Interestingly, some consumers valued brand reputation over blockchain verification, suggesting that blockchain alone is insufficient to build trust.

The quantitative findings showed a strong positive correlation ($r = 0.638$, $p < 0.001$) between consumer trust and purchase intention, confirming that higher trust leads to a higher likelihood of purchasing blockchain-enabled milk. Additionally, trust significantly predicted willingness to pay extra (Beta = 0.227, $p = 0.005$), although the effect was moderate rather than strong.

RQ4: **Does higher trust in blockchain-enabled QR codes lead to a greater willingness to pay more for milk products?**

The results confirm that higher trust in blockchain-enabled QR codes increases consumers' willingness to pay extra, although price sensitivity remains a limiting factor. The literature review suggests that perceived trustworthiness of a food technology significantly impacts consumer acceptance and premium pricing decisions (Treiblmaier & Garaus, 2022).

The qualitative interviews highlighted two opposing perspectives:

- Consumers who valued trust were willing to pay slightly more for blockchain-verified milk, especially if the price difference was under 10%.
- Price-sensitive consumers stated that trust alone was not enough to justify paying a premium, particularly if they already trusted the brand.

The quantitative analysis showed a weak-to-moderate positive correlation ($r = 0.277$, $p = 0.005$) between trust and willingness to pay more. While trust does increase willingness to pay, most consumers (55.3%) were not willing to pay extra. Instead, price competitiveness remains the dominant factor, meaning that blockchain verification adds value but does not justify high price premiums for most consumers.

Thus, the findings indicate that while trust is a critical enabler, blockchain must be combined with other incentives to drive greater willingness to pay.

5.2. Managerial Applications

Consumer trust is crucial for the adoption of modern technologies in the food industry, to improve trust in the food industry more specific the dairy one companies should implement educational campaigns highlighting how blockchain can enhance products traceability and food safety. This can be done with clear packaging information, in-store demonstrations where it is offered the opportunity for consumers to compare enabled blockchain QR Codes and traditional ones to highlight the added value and digital content with influencers explaining how the

technology works. In addition, partnerships with well-known certification identities to validate the claims made via the scan of enabled blockchain QR Codes. (Singh & Sharma, 2022)

To enhance the ethical concerns consumers are more worried about when purchasing a product, companies should do partnerships with organizations that well-known for their ethical and sustainable practices it can boost the credibility of blockchain technology. Such partnerships align brand values and enhance consumer trust. For instance, integrating blockchain with technologies like Augmented Reality (AR) and Virtual Reality (VR) can create immersive experiences that highlight a brand's commitment to sustainability and ethical sourcing, thereby strengthening consumer trust and engagement. (Patel, 2024)

Introducing blockchain-enabled products at prices comparable to traditional offerings can encourage consumer trial and adoption. Additionally, promotional strategies such as discounts or loyalty rewards can incentivize purchases. Research indicates that blockchain adoption can enhance product pricing strategies and platform efforts, particularly when consumers exhibit higher price tolerance, thereby improving overall quality efforts. (Tian & Hu, 2023)

Developing a premium line of blockchain-enabled products can attract market segments willing to pay more for ethically sourced and traceable items. Studies have shown that consumers' uncertainty about the value of green products can reduce their willingness to pay, thereby obstructing green product promotion. (Liao et al., 2024) Implementing blockchain technology can mitigate this uncertainty by providing transparent and verifiable information about product origins and sustainability practices.

Designing dedicated sections within stores equipped with interactive displays, such as touchscreens or tablets, allows consumers to scan QR codes and learn more about product origins and supply chains in an engaging manner. Integrating blockchain with AR and VR technologies in retail settings not only adds an element of gamification but also enhances customer interaction, making the shopping experience more informative and enjoyable. (Patel, 2024)

5.2. Limitations and Future Research

Since blockchain remains an abstract and complex concept, many respondents lacked prior knowledge, making it harder to assess their genuine perceptions. This knowledge gap may have influenced survey responses, as some participants may not have fully understood the technology’s potential applications and benefits. (Marikyan et al., 2022)

Given the technical nature of blockchain, conducting only in-depth interviews and surveys may not be sufficient to assess consumer perceptions comprehensively. A longitudinal study or more interactive methodologies, such as focus groups with real-time product demonstrations, could have provided richer insights. (Jun et al., 2025)

The sample was not fully representative of the Portuguese market, as most respondents were young adults, which limits the generalizability of the findings. Given that older generations may have lower digital literacy, their perspectives on blockchain adoption were underrepresented in the study.

The survey was distributed through the author's network, leading to a convenience sampling bias. Additionally, responses were collected in a non-controlled environment, meaning there was no supervision over how respondents interpreted and answered the questions. This may have introduced bias and inconsistencies in the data.

The study did not include expert interviews with retailers, psychologists, or industry specialists to provide a market-oriented or psychological perspective on blockchain adoption. These insights could have enriched the findings by exploring decision-making processes, consumer behavior patterns, and industry innovations in more depth.

Future studies should include a broader and more representative sample of the Portuguese market, covering different age groups, socioeconomic backgrounds, and nationalities. This will help determine if cultural factors influence blockchain adoption, particularly comparing Portuguese consumers with those from countries where blockchain use in food traceability is already more common.

Future research could implement focus groups where participants are presented with both traditional and blockchain-enabled QR codes in a controlled environment. This approach would allow for a more detailed explanation of blockchain technology and real-time interactions, ensuring that respondents have a clearer understanding of its benefits before providing feedback.

Conducting interviews with industry experts (e.g., retailers, psychologists, food scientists, and blockchain specialists) would provide deeper insights into how blockchain impacts consumer decision-making, the expected behavioral patterns in response to blockchain-enabled product labeling, and the potential for industry-wide blockchain adoption and its limitations.

6. Conclusion

The findings highlight the increasing importance of transparency and traceability in consumer purchasing decisions, with blockchain technology serving as a potential enabler of trust. While blockchain-enabled QR codes enhance perceived transparency, consumer awareness of blockchain remains relatively low, affecting the extent to which this technology influences purchase behavior. The results indicate that trust in blockchain-based QR codes significantly correlates with purchase intention. However, price remains the dominant factor, with many consumers hesitant to pay extra for blockchain-verified milk products. Ethical concerns, particularly those related to food safety and sustainability, positively influence trust but only moderately impact consumers' willingness to pay a premium price. Additionally, while familiarity with blockchain increases consumer trust, its direct effect on purchase decisions is weaker than initially expected.

From a managerial perspective, companies aiming to implement blockchain verification in food supply chains should invest in consumer education initiatives and strategic pricing models to enhance adoption. Collaborations with regulatory bodies, third-party certification organizations, and digital marketing campaigns could further boost consumer trust and engagement. Despite the promising implications of blockchain technology for food transparency, this study acknowledges several limitations, including a sample skewed toward younger consumers and a lack of direct industry expert insights. Future research should expand the sample size, explore other food sectors, and incorporate real-world product testing to better assess consumer behavior in response to blockchain-enabled traceability tools.

Ultimately, blockchain technology presents a viable opportunity to improve consumer trust and traceability in the food industry, but its full potential will depend on increasing awareness, aligning pricing strategies with consumer expectations, and ensuring that blockchain integration delivers meaningful value to end users.

Throughout the creation of this thesis, artificial intelligence techniques were used for tasks including content summarization, original material rewriting to improve clarity and conciseness, and text flow. The intellectual integrity of the research has been maintained at every stage, and all such use of Al was exclusively restricted to processing the author's own content.

7. Appendix

7.1. Interview

7.1.1. Interview Script

Start- Presentation	1. Purpose of Interview 2. Brief Explanation of the study and characteristics of centralized and decentralized QR Codes 3. Recording and Personal Information Collection (Name, Sex, Age, Living Place, Profession)
Psychographics	4. Do you consume dairy products? If so, how often? 5. Do you go to the grocery store to buy this type of product? If so, how often? 6. Do you have any dietary restrictions?
Initial Thoughts on QR Codes and Blockchain	7. How familiar are you with the use of QR codes on food packaging? 8.Have you encountered any products where blockchain technology is used to verify product information? If so, how did it influence your perception of the product?
***H3:* The integration of blockchain technology in QR codes increases milk consumers living in Portugal trust in milk products, with higher trust among milk consumers with food restrictions.**	
9. In your opinion, what elements make you trust, or distrust information displayed via QR codes on food packaging? 10. Do you feel that blockchain-integrated QR codes could increase your trust in food products? Why or why not?	
***H1:* Consumers who are more familiar with blockchain technology will have a bigger purchase intention to buy milk with a blockchain-enabled QR code.**	
11. When choosing food products, what factors influence your decision to buy? 12. If a product included a QR code providing blockchain-verified information (like source, quality, and traceability), how likely would it impact your choice to purchase that product? 13. Would you be more inclined to buy a product with a blockchain-enabled QR code over a similar product with a standard QR code? Please explain your reasoning.	

***H4: Milk* consumers living in Portugal with higher trust in blockchain-enabled QR codes will have a greater willingness to pay extra for milk products with blockchain verification.**
14. Would you be willing to pay more for a product that includes blockchain-verified information through a QR code? If so, why, and if not, what would deter you?
***H2: Milk* consumers living in Portugal who have higher ethical concerns regarding milk production will be more willing to pay extra for a blockchain-enabled milk product.**
15. How important is it for you to know the authenticity of the products you consume (such as origin and quality assurance)? 16. Would the presence of blockchain-backed QR codes on packaging increase your confidence in the product's authenticity?

7.1.2. Interview Participants resume

Person 1: Pedro Lobo Antunes, 22-year-old, Oeiras, Financial Risk Advisor, No Food Restrictions

Pedro Lobo Antunes, never heard of the integration of QR Code Technology in the food industry. The information he would like to see provided by a decentralized qr code information is temperature, production date, shipping, and storage conditions. Production information more precisely where it was produced and by who.

He says that companies that use QR codes with decentralized information can make him trust more in them, since he trusts in the blockchain system due to the fact it has more fairness and that it is more difficult to tamper with the inputs of a blockchain than with the ones uploaded via centralized information because companies have direct access to it and can possible manipulate it.

When asked if he would prefer to buy a centralized or decentralized product if both had similar characteristics, he prefers the one with decentralized information arguing it is more trustworthy in his point of view , but if the decentralized one was more expensive, he won't buy it maximum range of price difference he would buy would be a 10% price margin difference.

Factors influencing his purchase decisions when shopping by importance order are price; quality (trust brand or not if he already tried the product or not); packaging and quantity.

A valuable input provided to justify the strong trust showed in decentralized information during the interview was that the more information companies are willing to provide to consumers

even if some information can showcase the weaknesses and vulnerabilities of the product making it not that attractive, since the brand is being transparent about it owing it he would buy from them since they show all sides of their business.

He gave two examples of food scandals in Portugal and worldwide that made him rethink twice about the products he consumes:

- Nutella: studies appear claiming that palm oil causes cancer, so he stopped eating nutella;
- Ikea: the meat placed in the meatballs was replaced by horse meat but sold was cow meat, made Pedro stop eating Ikea meatballs due to leap in the brand and products trust;

Person 2: Madalena Pereira, 28 years old, Sintra, Veterinary, Gluten and Lactose Intolerant

Madalena has no knowledge of the implementation of centralized and decentralized QR codes in food industry, during the interview she was very proactive in responding since her biggest concern shared was the fear of consuming something that will trigger their allergies.

She gave an importance of 9 regarding food safety, due to past bad experiences like food poison, or mislabeling of ingredients, where she states that this technology will enable her to prevent it from happening again. Or if that is the case, she will be able to detect which part of the supply chain was the issue that caused her to feel ill.

Therefore, she places more emphasis on trusting brands that place decentralized QR codes on packing since even if their product does not have that much quality over others at least the company is showing that is transparent about that to their final consumers gaining their confidence. Stating that the brands that do so earn their trust and respect, she said she would choose between the same product offering the same price, with the difrrence of having centralized and decentralized information, the decentralized one. On fresh products she is willing to pay 2€ more for the product if the product provides her with trustworthy information. Since she feels safer by decentralized information products, her trust is bigger.

The main factors in terms of decision-making process when she is buying food products, especially fresh ones are certifications, like nutrition score like the A to E scale; source of ingredients used; price; products process.

Person 3: Maria Pereira, 33 years old, Cascais, Event Planner, No Food Restriction

Maria Pereira knows centralized information QR codes, in food processed products, she does not care much about the information being available but says if she checks it and has information such as source of origin, nutrition score it will be a plus to take in consideration in the decision-making process.

In terms of food safety, she rates it a 5, mainly because of fresh products, since she had past bad experiences regarding food illness and when buying products in that category, she indagates more than usually for information like transportation conditions and how the ingredients used were threated.

The main factors in terms of decision-making process when she is buying food products are price, quality, and packaging. She says she is willing to buy a decentralized QR code product when compared with a centralized one if the price range is not above a 5€ difference.

Person 4: Marta Matos, 22 years old, Oeiras, Graphic Designer, does not eat meat

No previous knowledge of the use of centralized or decentralized QR codes in food products. Information she would like to be able to check when she scans a QR code with decentralized information are: where the product was produced, if the was produced by local farmers (to being able to buy the healthiest choice possible with no chemicals in it).

Marta claims her trust would be bigger in companies that offer decentralized information since she would be able to check information about the different parts and different stakeholders trought the intire supply chain process, since the company places that information in a voluntary way her purchase decisions would be more informed.

Main factors when Marta is choosing food products are products being as whole foods as possible, packaging, price.

Person 5: Filipe Couto Pires, 23 years old, Carcavelos, Engineer, No Food Restriction

Filipe did not know any type of QR codes in food packaging. He would like to access the origins of the product when it was produced more precisely to know about the right validation date of the product.

Regarding trust towards the brand and products that use QR codes with decentralized information, he says we cannot trust more since he thinks it is bias if the company really places every information needed to know about consumers in a so claim clean way.

Main factors that Filipe has in consideration when shopping for food products is quality, price, brand.

He associates quality with the brand reputation established by his believes of previous experiences or insights gained by shared consumption experiences from friends and family, so when asked about the preference between centralized information and decentralized the decision will be based on the brand towards common positive experiences rather than on the information exposed to him.

Regarding, food security he values the decentralized QR Code to search for the possible cause of contamination when something happens to him regarding food poison, or other types of health problems that may arise due to poor transportation conditions, mislabeling of ingredients, overdue expiration dates.

Person 6: Nuno Carilho, 38 years old, Lisbon, HR Manager, No Food Restriction

Nuno knows QR codes with centralized information in brands like mimosa and terra nostra, that redirect him to the company website.

In terms of information, he would like to see things regarding the supply chain, especially the origin of the ingredients used, but information is from their origin to arriving at the factory, since he does not place as much trust in suppliers in comparison to producers.

Nuno would trust more in brands that use decentralized QR codes rather than centralized ones, since will provide him with information from the raw materials used in the final product that is not available normally in a product. He noted that he would only take in consideration buying products with decentralized information if he sees valuble in it, for example, he places bigger value in acquiring such in fresh and dairy products, since in his perspective for the product to have quality, it needs to have more care in the production process.

In terms of food security, Nuno trusts the legal layer meaning, the third parties involved in the Portuguese market, mentioning that the scope that makes him worried is the fact of the source of ingredients used.

Person 7: João Tiago Oliveira, 24 years old, Oeiras, Student, No Food Restriction

Jõao knows brands like Monster, Mimosa and Nestle that use QR codes with decentralized and centralized information in their food packing.

When mention what type of information he would like to see when scanning a decentralized QR code in fresh dairy products, he immediately says he wants to know everything about the raw materials, he gave the example of milk production, so he would like to be informed about how the cows are being treated, what is being given to them for eating, the transportation conditions. Placing an immense importance on knowing information about the raw materials here treated and produced.

João states he would trust more in a brand or product that uses decentralized information since nowdays products are manipulated more than ever with chemicals and are not as natural as he would like them to be, and with blockchain technology it will provide more stability to know trustworthy information about the product and if something is wrong with the product it's easier to track the source of the problem.

The main factors influencing João in the decision-making process is the quality-price relationship and the quality (how raw materials are treated).

He would buy a decentralized QR code in favor of a centralized one, if the difference in terms of price is not bigger than a margin of 25%.

Person 8: Miguel Lopes, 26 years old, Lisbon, Lawyer, does not eat meat

Miguel had previously knowledge of QR codes in food packaging, especiallyy small packages since the amount of space available there is shorter so he normally scanns the QR codes available to fetch nutritional information. He does not remember a specific brand but normally remembers seeing it in beverages.

Trust wise since once the information put there cannot be changed it will increase Miguel trust in the company since is not possible for them to distort the information available to final consumers like provenance and the whole supply chain until the product it is on the shelves to be in favor of what is being sold.

The information Miguel would like to have when he scans a QR code with decentralized information would be where it was produced, if the company is trustworthy, if they follow EU laws regarding food security, animals' wellbeing, and if there are any chemicals used in the making.

Miguel states that he will be willing to pay a lot more for a product with decentralized information, due to the fact that he can make the shopping experience a more informative one specially for products like dairy that have a lot of norms and laws that need to be done to have

the maximum security for the people who will acquire the product won't have any health products.

Factors Miguel has in consideration when choosing a product are: if the product is biological or not; if the product is produced in Portugal or in the European union; if it contains sugar or not; type of packaging; price.

Person 9: Sara Vieira, 37 years old, Lisbon, Data Analytics, Lactose Intolerant

Sara knows brands that use QR codes with decentralized information in their products in brands like Nestle in their baby food and coffee.

Information that Sara would like to have access when scanning a QR Code with decentralized information is nutritional information, certifications and ingredients used. Claiming that products that have certifications that she considers to be crucial regarding quality and process reassurance she automatically has more trust in the brand/product, in addition states that if the certifications can be claimed by a third part that can be accessed, for example in the decentralized QR code would make her feel even more safe specially in imported products. Also, she will see additional value in companies that invest in sustainable development towards consumer safety.

Factors considered in the decision-making process when buying food products: brand, price, nutritional characteristics.

When asked to choose between a product with centralized and decentralized information, which one she would prefer, she mention that besides the fact that she places a big value on real time trustworthy data in decentralized information, their final decision will be based on the brand that presents it since she values the existing experiences she already had with the brand rather than just trust in the information available. Sara will not pay more for a decentralized product if the brand asking for it will not be one that she already trusts.

In terms of food security, specially towards to dairy products she enhances a considerable importance into knowing when the product was made, the transportation process, the temperature the product is placed in-store, all this to prevent illness that may arise due to poor product safety conditions.

Person 10: Catarina Silva, 24 years old, Sintra, Recruitment, does not eat meat

Catarina had no previous knowledge about QR code with decentralized information. The type of information she would like to be able to access when she scanns a decentralized QR code is certifications, origin, nutricional composition, ingredients used to see if products are animal sourced or not.

She says she has more trust in brands that place decentralized information in their products because the more information they provide, the bigger trust brands place in the product they sell so not only enables brands to show their weaknesses and at the same time being stiffer about products placed in the market.

She is willing to pay more for the decentralized information, since for her it is important to know if the product, she is buying is animal sourced or not, and the conditions where the product has been transported and preserved.

A valuable insight provided by Catarina is that even though if she had to choose between a centralized and decentralized information QR code product, she would choose a decentralized one that would be only applicable in an initial phase of the decision-making process search for a preferred brand in a product category. Because once she found a brand that she likes she is loyal to it, but she is open minded to try other brands especially when the packaging is appealing giving her more confidence and quality in the product.

7.2. Survey

7.2.1. Survey Script

Introduction Message

Thank you for participating in this survey, which is part of my Master Thesis at Católica Lisbon School of Business and Economics. My research focuses on understanding consumer perceptions of blockchain technology and QR codes in the food industry, particularly in how they influence trust, purchase decisions. It will take approximately 5 minutes to complete, all responses are completely anonymous and confidential. The data collected will be used solely for academic purposes. If you have any questions, please feel free to reach out to me at s-mamapemartins@ucp.pt. By proceeding, you acknowledge and agree to participate in this study.

Screening Questions

SQ1, do you live in Portugal?

- o Yes (1)
- o No (2)

Skip To: End of Survey If Do you live in Portugal? = No

SQ3, do you consume milk (dairy or plant-based)?

- o Yes (1)
- o No (2)

SQ4 How often do you buy milk?

- o Daily (1)
- o 2-3 times a week (2)
- o Weekly (3)
- o Every two weeks (4)
- o Monthly (5)
- o Less often than monthly (6)

F1 Have you ever scanned a QR code on a milk product?

- o Yes (1)
- o No (2)

F2 Have you ever encountered blockchain technology in food products (for example milk products)?

- o Yes (1)
- o No (2)
- o Not Sure (3)

F3 How familiar are you with blockchain technology?

- o Not familiar (1)
- o Slightly familiar (2)
- o Somewhat familiar (3)
- o Neither familiar nor unfamiliar (4)
- o Moderately familiar (5)
- o Very familiar (6)

o Extremely familiar (7)

ES0

Price for a package of 1l of milk: 0,50€; 0,75€; 0,90€; 1,15€

Bio Logo Promoted by the European Union, recognizes that an article is produced organically ***Traditional QR Code (Centralized):*** This QR when scanned provides information via the company's website about the company that made the milk and how the milk is made in a certain company.

Blockchain-Enabled QR Code (Decentralized): This QR when scanned provides information about the product in front of you, indicating the actual time and duration of each production step, control quality, information about breeders.

Blockchain claim: Guarantees that the information concerning milk production is recored and stored in a blockchain system, in which cannot be changed or deleted.

Milk 1L for 1,15€ Vs ***Milk 1L for 0,75€***

ES2 Based on these descriptions, which milk product would you be more likely to buy?

o Milk with a traditional QR code (1)
o Milk with a blockchain-enabled QR code (2)
o Neither traditional nor blockchain (3)

ES3 If both products were priced the same, which one would you prefer?

o Blockchain QR Code Milk (1)
o Traditional QR Code Milk (2)
o Neither traditional nor blockchain (3)

ES4 Would you be willing to pay more for a milk product with a blockchain-enabled QR code?

o No, I wouldn’t pay extra (1)
o Up to 5% more (2)
o 6-10% more (3)
o 11-20% more (4)
o More than 20% (5)

PI1 How much do you agree with the following statements?

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
I would consider purchasing a milk product with blockchain enabled technology (1)	o	o	o	o	o	o	o
I intend to try to scan a milk product with enabled blockchain technology (2)	o	o	o	o	o	o	o
I plan on buying a milk product with	o	o	o	o	o	o	o

enabled blockchain technology (3)							
I am interested in finding more about information about the milk product via the enabled QR blockchain technology (4)	o	o	o	o	o	o	o
If I had the chance, I would buy a milk with enabled QR Code technology. (5)	o	o	o	o	o	o	o
In the future, I would like to buy a milk with enabled	o	o	o	o	o	o	o

QR Code technology. (6)	

EC0 These statements assess your personal ethical concerns when purchasing food products. Please indicate your level of agreement.

EC1 How much do you agree with the following statements?

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
It is important to me to find information to buy milk products with sustainability and animal welfare certifications. (1)	o	o	o	o	o	o	o
It is important to me to find ways	o	o	o	o	o	o	o

to check food fraud and product claims in milk products (2)							
How milk production may affect the environment and animals' welfare is important to me (3)	o	o	o	o	o	o	o

CT0 The following statements assess your trust in milk products based on packaging information. Please indicate your level of agreement.

CT1 How much do you agree with the following statements? (1 = Strongly Disagree, 7 = Strongly Agree)

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
I am more likely to	o	o	o	o	o	o	o

trust milk brands that use blockchain technology to ensure transparency. (1)							
I think that the milk with Blockchain QR Code can be trusted for its transparency and reliability. (2)	o	o	o	o	o	o	o
In general, I can rely on enabled blockchain QR Codes to provide transparency, and authentic information about the milk	o	o	o	o	o	o	o

supply chain (3)							
In general, I think that enabled blockchain QR Code can be trusted to assure that milk is of high quality. (4)	o	o	o	o	o	o	o

D1 What is your age?

- o Under 18 (1)
- o 18 - 24 (2)
- o 25 - 34 (3)
- o 35 - 44 (4)
- o 45 - 54 (5)
- o 55 - 64 (6)
- o Over 65 (7)

D2 What is your gender?

- o Male (1)
- o Female (2)
- o Non-binary / other (3)
- o Prefer not to say (4)

D3 What's your nationality?

- o Portuguese (1)
- o German (2)

o Other (3) _____

D4 What is your current ocupation?

o Student (1)

o Working Student (2)

o Employed (3)

o Unemployed (4)

o Retired (5)

o Independent Worker (6)

D5 What is your monthly income (gross)?

o I don’t receive a direct income (1)

o Less than 500€ (2)

o 500€ to 999€ (3)

o 1000€ to 1499€ (4)

o 1500€ to 1999€ (5)

o More than 2000€ (6)

D6 What is your highest level of education?

o High School (1)

o Undergraduate degree (bachelor or equivalent) (2)

o Graduate degree (Master or equivalent) (3)

o Professional degree (PhD or equivalent) (4)

D7, do you follow any food/dietary restrictions

☐ No (1)

☐ Vegetarian (2)

☐ Vegan (3)

☐ Lactose intolerant (4)

☐ Gluten intolerant (5)

☐ Only eat fish, don't eat meat (6)

☐ Other (7) _____

7.2.2. Survey Demographics and Characterization

Age Groups	Frequencie (N)	Percentage (%)
Under 18	4	3,9%
18-24	44	42,7%
25-34	28	27,2%
35-44	12	11,7%
45-54	13	12,6%
55-65	1	1%
Over 65	1	1%

Table 11 – Age Group Descriptives

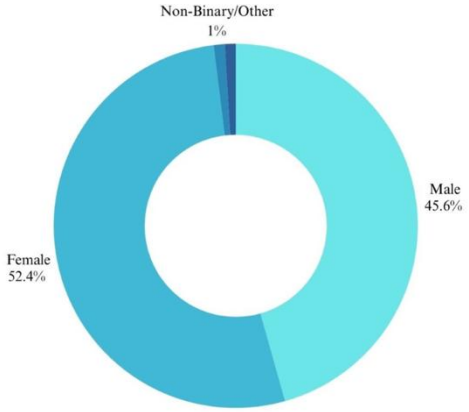

Figure 6 – Gender Descriptives

Nationalities	Frequencie (N)	Percentage (%)
Portuguese	97	94,2%
German	4	3,8%
French	2	1,9%
Italian	1	1,0%

Table 12 – Nationalities Descriptives

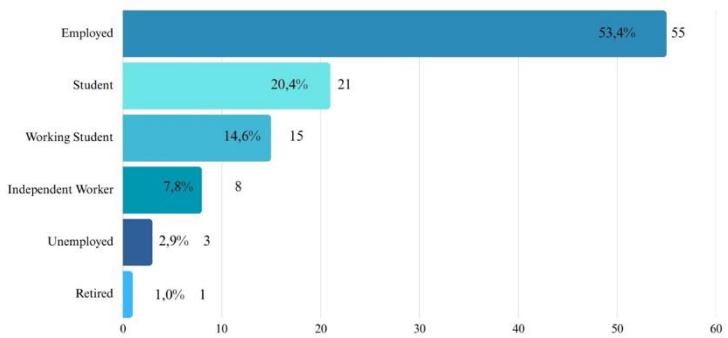

Figure 7 – Occupational Descriptives

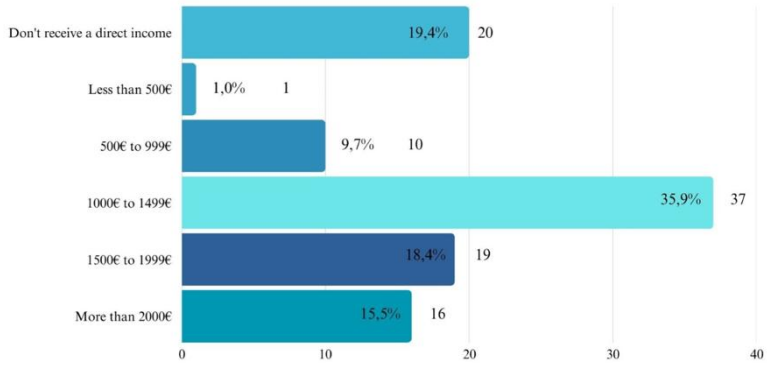

Figure 8 – Monthly gross income Descriptives

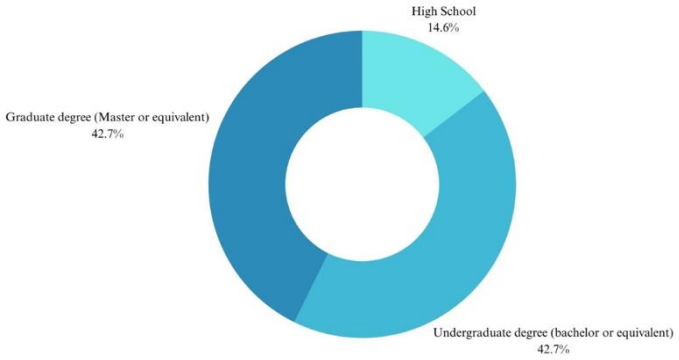

Figure 9 – Level of Education Descriptives

7.2.3. Survey SPSS Analysis Outputs

Correlations

			Purchase_Intention	Ethical_Concerns	Consumer_Trust	Food_Restrictions_Binary	Would you be willing to pay more for a milk product with a blockchain-enabled QR code?	If both products were priced the same, which one would you prefer?
Spearman's rho	Purchase_Intention	Correlation Coefficient	1.000	.323**	.638**	-.051	.372**	-.540**
		Sig. (2-tailed)	.	<.001	<.001	.608	<.001	<.001
		N	103	103	103	103	103	103
	Ethical_Concerns	Correlation Coefficient	.323**	1.000	.424**	-.007	.243*	-.166
		Sig. (2-tailed)	<.001	.	<.001	.944	.013	.093
		N	103	103	103	103	103	103
	Consumer_Trust	Correlation Coefficient	.638**	.424**	1.000	-.186	.304**	-.501**
		Sig. (2-tailed)	<.001	<.001	.	.060	.002	<.001
		N	103	103	103	103	103	103
	Food_Restrictions_Binary	Correlation Coefficient	-.051	-.007	-.186	1.000	.040	.117
		Sig. (2-tailed)	.608	.944	.060	.	.689	.240
		N	103	103	103	103	103	103
	Would you be willing to pay more for a milk product with a blockchain-enabled QR code?	Correlation Coefficient	.372**	.243*	.304**	.040	1.000	-.289**
		Sig. (2-tailed)	<.001	.013	.002	.689	.	.003
		N	103	103	103	103	103	103
	If both products were priced the same, which one would you prefer?	Correlation Coefficient	-.540**	-.166	-.501**	.117	-.289**	1.000
		Sig. (2-tailed)	<.001	.093	<.001	.240	.003	.
		N	103	103	103	103	103	103

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 10 – Correlation Matrix

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics			
					R Square Change	F Change	df1	df2	Sig. F Change
1	.264[a]	.070	.061	1.25811	.070	7.578	1	101	.007

a. Predictors: (Constant), How familiar are you with blockchain technology?

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11.994	1	11.994	7.578	.007[b]
	Residual	159.868	101	1.583		
	Total	171.862	102			

a. Dependent Variable: Purchase_Intention

b. Predictors: (Constant), How familiar are you with blockchain technology?

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	4.498	.226		19.944	<.001	4.050	4.945
	How familiar are you with blockchain technology?	.185	.067	.264	2.753	.007	.052	.319

a. Dependent Variable: Purchase_Intention

Coefficient Correlations[a]

Model			How familiar are you with blockchain technology?
1	Correlations	How familiar are you with blockchain technology?	1.000
	Covariances	How familiar are you with blockchain technology?	.005

a. Dependent Variable: Purchase_Intention

H1 Testing – Linear Regression Output

➔ **Nonparametric Correlations**

Correlations

			Ethical_Concerns	Would you be willing to pay more for a milk product with a blockchain-enabled QR code?
Spearman's rho	Ethical_Concerns	Correlation Coefficient	1.000	.243*
		Sig. (2-tailed)	.	.013
		N	103	103
	Would you be willing to pay more for a milk product with a blockchain-enabled QR code?	Correlation Coefficient	.243*	1.000
		Sig. (2-tailed)	.013	.
		N	103	103

*. Correlation is significant at the 0.05 level (2-tailed).

Case Processing Summary

		N	Marginal Percentage
Would you be willing to pay more for a milk product with a blockchain-enabled QR code?	No, I wouldn't pay extra	57	55.3%
	Up to 5% more	33	32.0%
	6-10% more	10	9.7%
	11-20% more	1	1.0%
	More than 20%	2	1.9%
Ethical_Concerns	2.00	2	1.9%
	2.67	3	2.9%
	3.00	1	1.0%
	3.33	1	1.0%
	3.67	1	1.0%
	4.00	6	5.8%
	4.33	2	1.9%
	4.67	4	3.9%
	5.00	11	10.7%
	5.33	5	4.9%
	5.67	7	6.8%
	6.00	30	29.1%
	6.33	9	8.7%
	6.67	5	4.9%
	7.00	16	15.5%
Valid		103	100.0%
Missing		0	
Total		103	

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	83.943			
Final	47.101	36.842	14	<.001

Link function: Logit.

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	16.000	42	1.000
Deviance	14.458	42	1.000

Link function: Logit.

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	16.000	42	1.000
Deviance	14.458	42	1.000

Link function: Logit.

Pseudo R-Square

Cox and Snell	.301
Nagelkerke	.344
McFadden	.172

Link function: Logit.

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Threshold	[ES4 = 1]	-.422	.479	.776	1	.378	-1.362	.517
	[ES4 = 2]	1.652	.524	9.944	1	.002	.625	2.679
	[ES4 = 3]	3.291	.732	20.236	1	<.001	1.857	4.725
	[ES4 = 4]	3.710	.838	19.608	1	<.001	2.068	5.353
Location	[Ethical_Concerns=2.00]	-19.530	9969.590	.000	1	.998	-19559.567	19520.507
	[Ethical_Concerns=2.67]	-1.199	1.319	.826	1	.363	-3.783	1.386
	[Ethical_Concerns=3.00]	.615	1.921	.102	1	.749	-3.150	4.380
	[Ethical_Concerns=3.33]	-19.530	.000	.	1	.	-19.530	-19.530
	[Ethical_Concerns=3.67]	.615	1.921	.102	1	.749	-3.150	4.380
	[Ethical_Concerns=4.00]	-1.199	.991	1.463	1	.226	-3.141	.744
	[Ethical_Concerns=4.33]	-19.530	9969.590	.000	1	.998	-19559.567	19520.507
	[Ethical_Concerns=4.67]	-19.530	7049.564	.000	1	.998	-13836.423	13797.362
	[Ethical_Concerns=5.00]	-1.343	.816	2.711	1	.100	-2.943	.256
	[Ethical_Concerns=5.33]	-19.530	6305.322	.000	1	.998	-12377.734	12338.674
	[Ethical_Concerns=5.67]	-.845	.893	.894	1	.344	-2.596	.906
	[Ethical_Concerns=6.00]	.501	.583	.740	1	.390	-.641	1.644
	[Ethical_Concerns=6.33]	-.362	.792	.209	1	.647	-1.915	1.190
	[Ethical_Concerns=6.67]	-19.530	6305.322	.000	1	.998	-12377.734	12338.674
	[Ethical_Concerns=7.00]	0[a]	.	.	0	.	.	.

Link function: Logit.

a. This parameter is set to zero because it is redundant.

H2 Testing Spearman's Rank Correlation and Ordinal Regression Output

T-Test

Group Statistics

	Food_Restrictions_Binary	N	Mean	Std. Deviation	Std. Error Mean
Consumer_Trust	.00	54	5.4861	1.05107	.14303
	1.00	49	5.0102	1.29095	.18442

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance				95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
Consumer_Trust	Equal variances assumed	1.422	.236	2.059	101	.021	.042	.47591	.23108	.01751	.93431
	Equal variances not assumed			2.039	92.727	.022	.044	.47591	.23339	.01243	.93939

Independent Samples Effect Sizes

		Standardizer[a]	Point Estimate	95% Confidence Interval	
				Lower	Upper
Consumer_Trust	Cohen's d	1.17122	.406	.015	.796
	Hedges' correction	1.18001	.403	.015	.790
	Glass's delta	1.29095	.369	-.027	.760

a. The denominator used in estimating the effect sizes.
Cohen's d uses the pooled standard deviation.
Hedges' correction uses the pooled standard deviation, plus a correction factor.
Glass's delta uses the sample standard deviation of the control (i.e., the second) group.

Oneway

ANOVA

Consumer_Trust

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.818	1	5.818	4.242	.042
Within Groups	138.547	101	1.372		
Total	144.365	102			

ANOVA Effect Sizes[a,b]

		Point Estimate	95% Confidence Interval	
			Lower	Upper
Consumer_Trust	Eta-squared	.040	.000	.136
	Epsilon-squared	.031	-.010	.128
	Omega-squared Fixed-effect	.031	-.010	.127
	Omega-squared Random-effect	.031	-.010	.127

a. Eta-squared and Epsilon-squared are estimated based on the fixed-effect model.

b. Negative but less biased estimates are retained, not rounded to zero.

H3 Testing – Independent Sample T-Test Output

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.277[a]	.076	.067	.824	.076	8.364	1	101	.005

a. Predictors: (Constant), Consumer_Trust

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.677	1	5.677	8.364	.005[b]
	Residual	68.556	101	.679		
	Total	74.233	102			

a. Dependent Variable: Would you be willing to pay more for a milk product with a blockchain-enabled QR code?

b. Predictors: (Constant), Consumer_Trust

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.578	.370		1.564	.121	-.155	1.312
	Consumer_Trust	.198	.069	.277	2.892	.005	.062	.334

a. Dependent Variable: Would you be willing to pay more for a milk product with a blockchain-enabled QR code?

Coefficient Correlations[a]

Model			Consumer_Trust
1	Correlations	Consumer_Trust	1.000
	Covariances	Consumer_Trust	.005

a. Dependent Variable: Would you be willing to pay more for a milk product with a blockchain-enabled QR code?

H4 Testing – Linear Regression Output

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