BLOCKCHAIN APPLICATION FOR TRACEABILITY AND OLIVE OIL PRODUCTION IN BRAZIL

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ABSTRACT

Goal: analyze the use of blockchain as a solution to improve the traceability of olive oil production in Brazil.

Theoretical Reference: The technology blockchain has the potential to store data immutably, eliminating the need for third-party verification. In the food industry, this technology can reduce food losses, control temperature during transport and increase the transparency of food-related processes.

Method: The first part is a bibliographical study that aims to identify the main applications of the technology blockchain in food traceability, with a specific focus on olive oil production, composing the mapping of the production chain.

Results: These results are expected to provide a solid basis for understanding the use of the blockchain in the traceability of olive oil production of olive.

Considerations: In the meantime, it is intended to demonstrate the effectiveness and potential benefits of the traceability system, mainly due to the existence of widespread fraud in the olive oil sector in Brazil, suggesting that the use of blockchain technology may be a promising approach to deal with this problem and protect consumers' interests.

Keywords: Blockchain, Olive Oil, Traceability.

APLICAÇÃO BLOCKCHAIN PARA RASTREABILIDADE E PRODUÇÃO DE AZEITE NO BRASIL

RESUMO

Objetivo: analisar o uso da blockchain como solução para melhorar a rastreabilidade da produção de azeite no Brasil.

Referência teórica: A tecnologia blockchain tem o potencial de armazenar dados de forma imutável, eliminando a necessidade de verificação por terceiros. Na indústria de alimentos, essa tecnologia pode reduzir as perdas de alimentos, controlar a temperatura durante o transporte e aumentar a transparência dos processos relacionados aos alimentos.

Método: A primeira parte é um estudo bibliográfico que visa identificar as principais aplicações da tecnologia blockchain na rastreabilidade alimentar, com foco específico na produção de azeite, compondo o mapeamento da cadeia produtiva.

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**Resultados:** Espera-se que estes resultados constituam uma base sólida para compreender a utilização da blockchain na rastreabilidade da produção de azeite de oliva.

**Considerações:** Entretanto, pretende-se demonstrar a eficácia e os potenciais benefícios do sistema de rastreabilidade, principalmente devido à existência de fraudes generalizadas no setor do azeite no Brasil, sugerindo que o uso da tecnologia blockchain pode ser uma abordagem promissora para lidar com este problema e proteger os interesses dos consumidores.

**Palavras-chave:** Blockchain, Azeite, Rastreabilidade.

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**1 INTRODUCTION**

An important point is the increase in the awareness of the population in relation to food safety and the quality of the food consumed. Currently, there is a concern on the part of consumers with aspects from the origin of the food consumed to the generation of tools that aim to ensure that these products are reliable and meet quality standards for purchases (ZHANG; MANKAD; ARYYAWARDANA, 2020), evidencing the need to improve communication between the different actors involved (BENITEZ et al., 2020; ROSSINI et al., 2021). In addition, enhanced professional skills are needed as there will be an increase in demand for management and intellectual skills due to reduced physical strength in the industrial environment. This is essential to solve the problems faced by the industry (SILVEIRA, 2018). Among the technologies, the use of blockchain proves to be a great tool for the industry (KAYIKCI et al., 2020; DE OLIVEIRA; KURESKI; SANTOS, 2023; DAROMES; NG, 2023).

The technology blockchain offers the possibility to store data in an immutable way, eliminating the need for third parties for verification (LIN et al., 2017). This technology has a promising application in the food industry, as it can help reduce food losses along the global supply chain, control temperature variations during transport and increase the transparency of food-related processes (KAYIKCI et al., 2020).

The use of technology blockchain, as a way of tracking extra virgin olive oil, is already widely used in countries such as Canada, Germany, the United States and Japan (IBM, 2020). In Brazil, some agribusiness data revealed that a significant portion of the investigated olive oil brands did not correspond to the information provided on their labels. This is concerning, as consumers rely on information on labels to make informed decisions about their food and health (OLIVE OIL TIMES, 2017).

In this context, it is evident the need for this study in which this technology will be used in the tracking and optimization of agribusiness, since there are no specific studies using blockchain in the processes of extra virgin olive oil in Brazil.

**2 THEORETICAL REFERENCE**

One of the papers important in the industry is the maintenance of equipment aimed at increasing production yield (O’DONOVAN et al., 2015; VOGL; WEISS; HELU, 2019). However, for a better performance of organizations to occur, it is necessary to develop effective methods and strategies for a better execution of activities, which, due to the absence of advanced information systems, entail in environments with high workloads and stress (LU, 2017). The advancement of digitalization, the internet and the most advanced technologies has caused...
changes in the business environment, especially in production and industrial models. These transformations gave rise to the so-called fourth industrial revolution or industry 4.0 (SADER; HUSTI; DAROCZI, 2022), with the objective of improving operational productivity and automation (LU, 2017).

The term "Industry 4.0" was mentioned for the first time in 2011, in Germany, during the event "Hannover Fair", as a proposal for the development of a new concept of economic policy based on high technology strategies. This proposal symbolized the beginning of the Fourth Industrial Revolution (CARVALHO et al., 2018). The tools used in Industry 4.0 have the function of receiving, collecting, managing, analyzing, interpreting and communicating large volumes of information coming from all parts of the production system. In addition, these tools are responsible for executing decentralized decisions and allowing the simulation of the entire supply chain and related processes, aiming to make efficient decisions (DOPICO et al., 2016).

Industry 4.0 aims to connect human resources, services and machines in real time throughout the entire production process, based on cyber-physical systems (CPS) and the Internet of Things (IoT). The physical components are complemented by sensors, actuators and software embedded, giving them the ability to process and communicate data. It is known that the repercussions of modernization will have an impact on the human lifestyle, and the period of the fourth industrial revolution will be characterized by complete processes of automation and digitization, using electronics and technological information (REZEK et al., 2021).

Therefore, during this period, it will be possible to gather and analyze data between machines, which will result in faster, more flexible and efficient processes for the production of higher quality products at reduced costs (HUSTI; DAROCZI, 2022).

According to Lee, Kao and Yang (2014), the fourth industrial revolution has a significant impact in four areas. First, industrial management becomes more organized and transparent due to the greater level of information across sectors. Right away, the management of production and maintenance is improved with the help of solutions that allow the prediction of the health of the machines and provide prognostic information. These tools allow anticipating maintenance problems, optimizing the efficiency of production processes and reducing costs related to failures and non-intuitive stops. The third area is human resources, which will be impacted by this new trend, addressing labor costs and promoting a healthier work environment. Ultimately, costs are eventually reduced due to energy savings and optimization of maintenance planning and logistics management.

Agribusiness is involved in the global economic sector, from the food production chain to the connection of various sectors (agricultural, livestock, industry and trade). According to IBGE (2021), in 2021 agribusiness was part of 27.4% of Brazil's GDP, the highest rate since 2004. However, there are several challenges that agribusiness needs to face, from activities involving increasing production rates, as well as sustainability, which has generated an increase in the search for technologies and innovation in the area (BARRETO et al., 2021; DE SOUZA; CUNHA; DINARDI, 2023). In the meantime, the authors Souza et al. (2022) point out the importance of discussions involving the agricultural issue with education and teaching, in order to broaden discussions of these spheres in the social sphere, elucidating the Brazilian Biomes in their production contexts.

In addition to agribusiness being linked to an important role in the quest to reduce impacts on the natural environment, it is also linked to some challenges, in the next 50 years, such as energy, water, food, environment and poverty. From this perception, it is evident the importance of carrying out the transformation of the agri-food industry, as a way of transforming fundamental guidelines such as digitization and greening, it is in need of understanding of these aspects (SCHNEBELEN; LABARTHE; TOUZARD, 2021). A digitization of the agri-food industry, in turn, is used in the application of digital solutions in
the food production chain and is often left to the development of the fourth industrial revolution (LIU et al., 2021), being considered an important tool to achieve environmental, biological and sustainability goals as a whole, due to increased production efficiency, lower costs and improved coordination (EL-BIALI; ALLANHYARI, 2018). However, on the other hand, the greening guideline in the agribusiness sector requires the use of tools and technologies that not only mitigate the environmental impact in the food production chain, but also in the restoration and maintenance of ecosystem services (SCHNEBELIN; LABARTHE; TOUZARD, 2021).

An important point is the increase in the awareness of the population in relation to food safety and the quality of the food consumed. The concern on the part of consumers goes from aspects of the origin of the food consumed to the generation of tools that aim to ensure that these products are reliable and meet quality standards. This demand highlights the need for traceability systems that generate more reliable certifications, which allow consumers to make informed decisions about their purchases (ZHANG; MANKAD; ARIYAWARDANA, 2020).

As a way to meet the consumer population's demand for safer certifications and traceability systems in the production chain, the technology Blockchain turns out to be an interesting tool. In addition to this technology generating great confidence, they do not require a centralized authority, having the potential to track the location of origin of agricultural products, from cultivation to the consumer. Studies in the area (ISMAIL; MATERWALA, 2019; TREIBLMAIER; BECK, 2019) have demonstrated the applications and benefits of Blockchain in the food supply chain as a whole.

Below are some features related to the blockchain:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Us</td>
<td>The nodes are part of the technological structure blockchain which functions the exchange of data in a synchronous way and the storage of a copy, thus, all nodes in the network are updated, in a real way, maintaining consistency due to the characteristic of this data exchange.</td>
<td>Kramer et al. (2021)</td>
</tr>
<tr>
<td>Decentralized</td>
<td>The blockchain is structured in a way without having a center because there is not only one server grouping all the available information, on the contrary, the information is stored as copies in several places in the network. This feature makes the system complex, because even if a computer has problems, the system remains active.</td>
<td>Kramer et al. (2021)</td>
</tr>
<tr>
<td>Block storage</td>
<td>The information, by the nodes of the system, is stored collectively. Any user can become a node after doing the Login online and be approved by the parties involved.</td>
<td>Tonkin et al. (2020)</td>
</tr>
<tr>
<td>Reliable</td>
<td>This technology is reliable because each node is duplicated (copy) completely in the database, which remains as a sub-database, creating layers of security.</td>
<td>Kramer et al. (2021)</td>
</tr>
<tr>
<td>Anonymous</td>
<td>the identity of each node is kept anonymous, which means that the transactions and interactions carried out by each node do not reveal personal information or identifiable information about their owners.</td>
<td>Kramer et al. (2021)</td>
</tr>
</tbody>
</table>

Source: Adapted of Kramer et al. (2021) e Tonkin et al. (2020).

The traceability unit, also known as the Traceable Resources Unit (TRU), which is unique for each supply chain and can be determined by national regulations and the structure of each chain, is of great importance in the traceability of the supply chain. agri-food supply (FREITAS; VAZ-PIRES; CÂMARA, 2020; MOTTESE et al., 2020).

However, some disadvantages of using Blockchain digital traceability were also partially evaluated. One of the main concerns the cost of Blockchain, which can lead to an increase in the price of products that are supplied with digital traceability (LI et al., 2019). There is evidence that the market can absorb the associated price increase in traceability digital, as
mentioned by Violino et al. (2019). In their study, several consumers found a price increase of 17.8% acceptable for a product provided with digital traceability. In addition, it is important to carefully evaluate the potential misuse of data from the Blockchain companies to create profiles. Previous studies (REJEB; KEOGH; TREIBLMAIER, 2020) highlighted this concern related to privacy and unauthorized use of user data Blockchain.

For a proper evaluation, it is essential that each case study on the use of the Blockchain provides a clear rationale for applying the technology, specify the type of BCTs (Blockchain Technologies) used, discuss the challenges encountered throughout the study and how these challenges influenced the results obtained. In addition, the results must be presented and discussed properly, taking into account the specific type of case study, in order to make them useful for future research or industrial projects. These guidelines can be found in previous studies, as mentioned by Treiblmaier (2019).

3 BLOCKCHAIN IN THE OLIVE OIL PRODUCTION CHAIN

As a way of generating support and the development of production and consumption, it is technology Blockchain proves to be a great tool, as it can improve communication, cooperation and coordination between the different stages of the supply chain, with the inclusion of consumers. Regarding extra virgin olive oil, using a traceability system based on blockchain can be useful to improve existing control systems, such as certifications (VIOLINO et al., 2019; FERNANDES et al., 2022).

The process of tracking quality characteristics in the olive oil sector plays an important role, allowing to guarantee and highlight the origin of products and raw materials, also covering the identification of the diversity of olives. This process is important as it protects consumers against fraud and generates confirmation of the authenticity and quality of the oil (MUZZALUPO et al., 2015). In early 2020, the company CHO made an announcement showing the use of the platform blockchain from IBM to track the entire production process of its extra virgin olive oil. From the blockchain, the company is able to follow the entire production and shipment of olive oil, from the cultivation process in the orchards in Tunisia, to consumers in several countries, including Canada, United States, Germany, France, Denmark and Japan (IBM, 2020).

In Italy, the application called BRUSCHETTA was created, which is based on the technology blockchain with the objective of tracking and certifying the production of extra virgin olive oil - EVOO (Extra Virgin Olive Oil). This kind of technology plays an important role as it ensures great quality and authentic products. The application is available to everyone, which allows developers, specialists and general interested parties to review, contribute and use the application. This can promote collaboration and continuous system improvement, as well as increase the transparency and reliability of EVOO traceability (ARENA, 2019).

In Brazil, Lucena and Henriques (2019) highlighted the advantages of implementing a business network based on blockchain for agricultural exports. This platform has the ability to assist producers in tracking grain stored in warehouses, optimizing trade with global exporters and allowing a better flow of information between participants in the business network. It is important to make it clear that, so far, no specific articles have been located in Brazil that demonstrate the application of the technology blockchain on the traceability of extra virgin olive oil. This lack of national studies demonstrates the need for research and investigation in this business network, mainly due to the report that revealed that 45 of the 140 brands of olive oil did not indicate the information provided on their labels in Brazil, and it was verified that some of these products contained an ingredient that is not suitable for human consumption (OLIVE OIL TIMES, 2017).
Against this backdrop, this work purpose analyzes the use of blockchain as a solution to improve the traceability of olive oil production in Brazil. In this perspective, the study is based on a master’s thesis from the Federal University of Rio Grande (FURG) in front of the Graduate Program in Agroindustrial Systems and Processes (PPGSPA).

4 METHODOLOGY

The methodology addressed in this work will be divided into two parts: systematic review and experimental methodology. This part is a bibliographic study that aims to point out the main applicability of blockchain technology in food traceability, with emphasis on olive oil production. The systematic review method will be adopted (figure 1), in which it contributes to the process of analysis and structuring of the acquired information.

Data collection will be carried out in August 2023, based on searches in the databases: Scopus, web of science and Science. It is science direct using combinations of Boolean terms, descriptors and operators. From the search results, before creating the database, the titles and abstracts will be read as a way of filtering the selected articles. The articles included will be original, of a qualitative and/or quantitative nature and published in English, based on inclusion and exclusion criteria. The analysis of data extracted from the articles will be done in a descriptive way, aiming to gather the knowledge produced on the topic addressed.

As an agricultural product, extra virgin olive oil will be used, which was chosen due to the lack of correspondence in the information provided on the labels by many companies in Brazil (OLIVE OIL TIMES, 2017). The mapping phase will be carried out showing the critical points of the production chain, such as: producer, carrier, industry, commercialization and consumer.

The creation of the product traceability method, using technology blockchain, will start with the setup of the work environment. In this step, the necessary environment to implement the blockchain solution will be configured. This will involve installing and configuring the components and tools necessary for the system to function properly. In addition, the extra virgin olive oil chain will be mapped. This means identifying and understanding all the stages and actors involved in the production, processing, distribution and marketing of the product (figure 2).

During the construction phase of the data network, the use of a personal computer will be used to carry out the development of the backend. In this step, it will be necessary to install...
Node.js (a development platform based on the programming language JavaScript). This platform will be used to create the logic of the blockchain, which enables the processing and manipulation of network data, offering several resources and libraries that facilitate the development of applications. By using Node.js as a technology blockchain, it will be possible to manage and build the right infrastructure to run an efficient and customized data network.

**Figure 2.** Flowchart of the process of creating the traceability method

![Flowchart of the process of creating the traceability method](image)

Source: Adapted from Silva (2020).

The efficient interaction between supply chain elements in the context of blockchain technology will be facilitated by the development of a Web Service. This approach allows that blockchain be accessed and used regardless of the platform or device used by the entities. As a way of connecting those involved in the supply chain to the blockchain, Web Service Aims to act as an interface, promoting this connection in a safer way. As a way of frontend, we opted to use react.js, which is a framework, and its function is to promote developers to create large-scale applications with the possibility of changing data without having to reload the page, aiming to provide a fast, scalable and simple experience for creating user interfaces. In this context, the frontend developer with React.js has a great function in viewing and exploring the blocks registered within this technology, allowing those who access it to view and interact with the data stored on the platform, in an intuitive and friendly way, which facilitates the exploration and understanding of the information contained in the blocks.

In the study, a questionnaire will be applied with the objective of evaluating the knowledge of consumers and buyers of the oil extra virgin olive oil from the region. The questionnaire will consist of open and closed questions, addressing topics such as the use of olive oil, the quality of the product, knowledge about the objectives of the technology blockchain and the presentation of the developed prototype. For closed answers, the Likert scale will be used, which consists of a five-point evaluation scale (poor, could be improved, good, very good and excellent). This scale will allow respondents to express their opinion on the efficiency and benefits of the prototype Blockchain.

The questionnaire will be created and made available on the Google Forms platform, facilitating access and completion by participants. The distribution of the questionnaire will be carried out through social networks and also by email, directed to buyers linked to the olive oil production company. The application of the questionnaire will provide important information about the knowledge and perception of consumers and buyers in relation to extra virgin olive oil, as well as the acceptance and effectiveness of the prototype blockchain developed. These
data will help to assess the feasibility and potential of using the technology *blockchain* traceability and optimization of olive oil production.

5 RESULTS

From the systematic review, the use of the *blockchain* in food traceability, specifically in the production of olive oil. Studies and cases, which use the *blockchain* as a way to improve traceability in the food industry, with a focus on the olive oil sector, will be identified and analyzed, with the main benefits and challenges associated with the use of the *blockchain* in this context.

Innovations related to the use of *blockchain* in food traceability, such as the development of integrated solutions that combine *blockchain* with other technologies for generating a broader and more efficient tracking system, will be addressed. The main results and conclusions will be presented, providing insights important for researchers and professionals in the olive oil sector about the reality, opportunities and challenges of using olive oil *blockchain* in food traceability.

A traceability system prototype will be developed, based on *blockchain* adapted to the production of olive oil. The prototype will have the specific characteristics of the olive oil production chain, such as steps in the cultivation, harvesting, processing and distribution process. Critical information to be recorded in the *blockchain*, such as data on origin, quality, production methods, transport and storage.

It is expected that from the results of the questionnaire, the knowledge, perceptions and opinions of consumers in relation to olive oil and *blockchain* technology increase by helping to understand consumer receptivity towards the use of innovative technologies in the olive oil industry and providing prototype improvements or tweaks to *blockchain* development. These expected results will provide a solid foundation for understanding the use of the *blockchain* in the traceability of olive oil production, demonstrating the effectiveness and potential benefits of the traceability system based on *blockchain* developed.

6 CONCLUSION

The use of *blockchain* technology, aiming at tracking the production of extra virgin olive oil in Brazil, demonstrates challenges and potential that should be studied. One of the main advantages is better transparency and trust in the olive oil production chain. With a system based on *blockchain*, it is possible to follow the entire process, from the stage of planting the olive trees to the final product. This allows the availability of access by consumers, mainly to detailed information about olives, agricultural processes, olive oil extraction methods and quality certifications.

The technology *blockchain* generates more security against counterfeiting and fraud. Transactions stored in blocks are immutable and verifiable, ensuring the identification of problems, incorrect labeling and adulteration of oils in the Brazilian market. However, it is important to take into account the barriers and limitations on the use of *blockchain* for tracking olive oil in Brazil. A successful implementation requires the participation and cooperation of everyone involved in the chain, from olive producers to sellers. It is necessary to demonstrate standards and protocols for data collection and availability, in addition to investing in adequate technological infrastructure. It is essential to generate activities aimed at raising awareness and educating consumers about the importance of traceability of olive oil and how to use the information to make informed choices. Trust in technology *blockchain* and on the recorded information depends on the understanding-engagement relationship of consumers.

The use of *blockchain* for tracking the production of extra virgin olive oil in Brazil has the potential to improve transparency, reliability and product quality, making it necessary to
face the challenges and involve all participants in the chain to ensure the effectiveness and success of the implementation. Fraud in the olive oil production chain is a concern worldwide, and some data show that Brazil also faces these challenges. Counterfeiting and adulteration can have a negative impact on those who consume olive oil, causing damage to the relationship with the industry and the quality of products available on the market. In this context, the use of blockchain technology for tracking the production of extra virgin olive oil is revealed as a possible solution to guarantee characteristics such as transparency, authenticity and security of products.

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