DEVELOPMENT OF A DIGITAL TRACEABILITY SYSTEM IN THE COFFEE PRODUCTION CHAIN USING QR CODES

DESENVOLVIMENTO DE UM SISTEMA DIGITAL DE RASTREABILIDADE NA CADEIA PRODUTIVA DO CAFÉ POR MEIO DE QR CODE

DESARROLLO DE UN SISTEMA DE TRAZABILIDAD DIGITAL EN LA CADENA PRODUCTIVA DEL CAFÉ USANDO CÓDIGOS QR

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ABSTRACT

Traceability has become an essential requirement in the coffee production chain, driven by the growing demand for transparency and product quality. Small rural properties, however, face difficulties in adopting traceability technologies due to cost, limited digital infrastructure, and technical complexity. This study aimed to develop a simple and functional web system to track coffee batches using QR Codes as digital identifiers. The research followed an applied and technological approach, based on a literature review and software development. The system was implemented using the Python programming language and the Django framework, supported by an integrated database and web hosting to ensure accessibility. Simulated data representing the production process of a small rural property were used to maintain ethical compliance and avoid the need for research ethics committee evaluation. The resulting system, named RastreCoffee, enables the registration of coffee batches, recording of production information, and automatic generation of QR Codes readable by mobile devices. The results demonstrated that digital traceability can be applied to family farming in an accessible and low-cost manner. The proposed solution promotes technological inclusion, adds value to the product, and strengthens trust between producers and consumers, while also presenting potential for future enhancements.

Keywords: Traceability. Coffee. QR Code. Family Farming. Django.

RESUMO

A rastreabilidade tem se consolidado como um requisito essencial na cadeia produtiva do café, especialmente diante das exigências de transparência e qualidade por parte do mercado consumidor. Entretanto, pequenas propriedades rurais enfrentam dificuldades para acessar tecnologias de rastreabilidade devido a fatores como custo e complexidade técnica. Este projeto teve como objetivo desenvolver um sistema web simples e funcional voltado à rastreabilidade de lotes de café, utilizando QR Code como identificador digital. A pesquisa teve abordagem aplicada e caráter tecnológico, fundamentada em revisão bibliográfica e desenvolvimento de software. O sistema foi implementado utilizando a linguagem Python e

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o framework Django, com banco de dados integrado e hospedagem em ambiente web para facilitar o acesso. Durante o desenvolvimento, dados simulados foram empregados para ilustrar o processo de produção de uma pequena propriedade rural, mantendo a conformidade ética e evitando a necessidade de submissão ao comitê de ética. O sistema desenvolvido, denominado RastreCoffee, permite o cadastro de lotes de café, registro de informações produtivas e geração automática de QR Codes, que podem ser lidos por dispositivos móveis para acesso às informações. O resultado demonstrou que é possível aplicar rastreabilidade digital na agricultura familiar de forma acessível e com baixo custo operacional. Conclui-se que a solução proposta contribui para a inclusão tecnológica no campo, agregação de valor ao produto e fortalecimento da confiança entre produtor e consumidor, além de apresentar potencial para expansão futura com novas funcionalidades.

Palavras-chave: Rastreabilidade. Café. QR Code. Agricultura Familiar. Django.

RESUMEN
La trazabilidad se ha convertido en un requisito esencial en la cadena de producción de café, especialmente dadas las exigencias de transparencia y calidad del mercado de consumo. Sin embargo, las pequeñas propiedades rurales enfrentan dificultades para acceder a tecnologías de trazabilidad debido a factores como el costo y la complejidad técnica. Este proyecto tuvo como objetivo desarrollar un sistema web simple y funcional para la trazabilidad de lotes de café, utilizando códigos QR como identificadores digitales. La investigación tuvo un enfoque aplicado y tecnológico, basado en una revisión bibliográfica y el desarrollo de software. El sistema se implementó utilizando el lenguaje Python y el framework Django, con una base de datos integrada y alojamiento web para facilitar el acceso. Durante el desarrollo, se utilizaron datos simulados para ilustrar el proceso de producción de una pequeña propiedad rural, manteniendo el cumplimiento ético y evitando la necesidad de presentarlo ante un comité de ética. El sistema desarrollado, denominado RastreCoffee, permite el registro de lotes de café, el registro de información de producción y la generación automática de códigos QR, que pueden leerse mediante dispositivos móviles para acceder a la información. El resultado demostró que es posible aplicar la trazabilidad digital en la agricultura familiar de forma accesible y con bajos costos operativos. Se concluye que la solución propuesta contribuye a la inclusión tecnológica en el campo, agrega valor al producto y fortalece la confianza entre productor y consumidor, además de mostrar potencial de expansión futura con nuevas funcionalidades.

Palabras clave: Trazabilidad. Café. Código QR. Agricultura Familiar. Django.

1 INTRODUCTION

Coffee growing is one of the main economic activities in Rondônia, since its production has a great influence on the livelihood of families of small and medium-sized producers, especially in the city of São Miguel do Guaporé, where, according to data from the Brazilian Institute of Geography and Statistics (IBGE), in 2023 the municipality stood out as the largest coffee producer in the state, with a production of 49,646 tons (IBGE, 2023). With the increase in competitiveness in the coffee market, the demand for transparency and quality in all stages of the production process also grows.

In this sense, traceability has been consolidated as an essential requirement, as it allows you to follow the trajectory of the product from its origin to the final consumer. According to Embrapa (2006), traceability is defined as "the ability to trace the history, application, or location of an item through previously recorded information". This process promotes safety, standardization, and strengthens consumer confidence. As Puglia points out (GLOBO RURAL, 2018), "consumers are increasingly engaged with the origin of what they eat".

Despite their importance, most of the traceability systems available are aimed at large producers and cooperatives, making it difficult for small and medium-sized producers to access them due to the high cost of implementation and the need for specialized technical support. To democratize this access, it is necessary to develop simple, efficient and low-cost solutions, capable of meeting the demands of family farming.

In view of this scenario, this project presents the development of the RastreCoffee system, a digital solution based on the use of QR Code to record and make available the stages of the coffee production process. The system was developed using hypothetical data, to simulate the reality of a small rural property without the need to identify real people or places, preserving the ethical-academic character of the study. The use of QR Code was chosen for its accessibility and ease of use, since it can be quickly read by the camera of any smartphone to access product information (EMBRAPA, 2023; BITLY, 2025).

The justification for this project is based on the need to promote technological inclusion in the field, adding value to coffee and strengthening the competitiveness of small producers in the market. In addition, traceability contributes to the transparency of the production chain and can meet certification requirements, facilitating the insertion of the product in more demanding markets.

The general objective of this study was to develop a digital traceability system for coffee lots using QR Code technology.

The specific objectives are:

- Model and develop a web system using Python and the Django framework with integrated database;
- Implement the automatic generation of QR Codes linked to the registered lots;
- Simulate real data from coffee production stages for use in the system;
- Make traceability information available to the consumer through an accessible web interface.

2 THEORETICAL FRAMEWORK

2.1 IMPORTANCE OF COFFEE GROWING IN BRAZIL AND RONDÔNIA

Coffee is one of the most relevant products for Brazil's economy, being recognized as one of the country's main export commodities. According to the National Supply Company (CONAB, 2023), Brazil is the world's largest producer and exporter of coffee, with emphasis on the species *Coffea arabica* and *Coffea canephora*. In the context of Rondônia, coffee growing has been consolidated as one of the main agricultural activities since the 1970s, with agricultural colonization programs. According to data from the Brazilian Institute of Geography and Statistics (IBGE, 2020), the state already occupied the 5th position in the national ranking and was the second largest producer of *Coffea canephora* in the country, contributing significantly to the generation of employment and income, especially in family farming.

2.2 MODERNIZATION AND TECHNOLOGIES IN PRODUCTION

In recent decades, Rondônia's coffee growing has undergone a modernization process that has been increasing productivity and improving the quality of coffee produced in the state. According to Lopes Júnior et al. (2023), between 2010 and 2020 there was a significant increase in the productivity of coffee crops in Rondônia, even with the reduction in the planted area. This advance is the result of the adoption of technologies such as high-performance clonal seedlings, irrigation systems, sustainable soil management, and integrated pest and disease control.

Another important factor for the evolution of coffee growing in the state was the adoption of good agricultural practices and access to technologies developed by research

institutions. Embrapa Rondônia (2023) has been one of the main responsible for the dissemination of technologies aimed at coffee, such as the implementation of agroforestry systems, the use of balanced fertilization, fertigation, and correct pruning management. In addition, programs such as "Sustainable Robusta Coffee" and the installation of Technological Reference Units (URTs) have enabled small producers to adopt modern cultivation techniques even with few financial resources.

2.3 TRACEABILITY AS INNOVATION AND ADDED VALUE

Traceability has become an essential requirement in the agri-food market, as it allows you to follow the path taken by the product from its origin to the final consumer. According to Embrapa (2023), traceability enables greater control of production stages, ensuring reliable records and ensuring that the product follows established quality and compliance standards. As Puglia points out (GLOBO RURAL, 2018), "consumers are increasingly engaged with the origin of what they consume".

Recent research shows that traceability has been widely adopted as a tool for market differentiation. According to Santos et al. (2021), rural properties that use some type of traceability system have greater acceptance in the market and achieve better prices in marketing. Souza and Martins (2022) state that traceability increases the control of the production process, reduces losses, and facilitates the identification of failures, contributing to agricultural planning. Oliveira and Souza (2020) highlight that, despite the advances, traceability still faces challenges for its adoption in small properties due to the lack of digital inclusion in the field.

2.4 QR CODE TECHNOLOGY APPLIED TO AGRICULTURAL TRACEABILITY

The QR Code is a two-dimensional coding technology that allows for quick reading of information through mobile devices. According to Embrapa (2023), the QR Code facilitates access to real-time data, making it a strategic tool for traceability and transparency. As the Bitly platform (2025) highlights, "by adding QR Codes to packaging, agricultural brands can bridge the trust gap".

Souza et al. (2022) state that the QR Code is a viable alternative for agricultural traceability because it is low-cost and easy to implement. Oliveira and Silva (2021) reinforce that the QR Code strengthens the relationship between producer and consumer by allowing access to information on the origin of the product. For GS1 Brazil (2023), the QR Code is

compatible with international identification and traceability standards, and is recommended for production chains seeking certification and authenticity.

2.5 DIGITAL TECHNOLOGIES IN THE DEVELOPMENT OF WEB SYSTEMS

With the advancement of technology, computerization in the field has become necessary to keep up with the evolution of agricultural practices. According to the DataCamp portal (2023), "Python is a powerful, flexible, and incredibly versatile language." Its ease of learning and extensive community make it a good choice for developing affordable solutions.

The Django framework complements this technology by allowing the creation of web systems quickly and securely. According to MDN Web Docs (2025), "Django is a high-level Python web framework that enables the rapid development of secure and maintainable websites." The integration of Python and Django makes it possible to build systems such as RastreCoffee, aimed at agricultural traceability with automatic generation of QR Codes.

Based on the reference presented, it is observed that traceability is an essential practice to add value to coffee and meet the demands of the current market. The use of QR Code has become an efficient and affordable solution, and can be implemented through digital technologies such as Python and Django. In this way, the development of the RastreCoffee system integrates theory and practice, allowing the application of the concepts addressed in this chapter in the context of family farming.

3 METHODOLOGY

3.1 TYPE OF RESEARCH

This study is characterized as an applied research, as it aims to develop a practical solution aimed at meeting a real need found in the context of family farming: the lack of accessible traceability for small coffee producers. The approach is qualitative, since it is not based on statistical analysis, but on the interpretation of the processes involved in the development of the system and on the evaluation of its applicability. As for the objectives, this is a descriptive research, as it seeks to expose the characteristics of the developed system and its functioning. In addition, it has an experimental character, since it involves the creation, implementation and validation of a functional prototype of the RastreCoffee system applied in a simulated context of rural production.

3.2 METHODOLOGICAL PROCEDURES

The development of this project took place in organized and interdependent stages. Initially, a theoretical survey was carried out on traceability, family farming, use of QR Code and technologies applied to web development. Then, the system requirements were defined, determining the functionalities necessary to meet the objective of the study.

After planning, the implementation phase began. The Python programming language was adopted with the Django framework, due to its robustness, security, and ease of integration with the database. PostgreSQL was used to store the information, and the Qrcode library was used to generate the identification codes. All development was done in a local environment using the Visual Studio Code (VS Code) editor, with version control performed via GitHub. After local tests, the system was implemented in a web environment through the Render platform, enabling public access to the project.

3.3 DEVELOPMENT ENVIRONMENT

The RastreCoffee system was developed in a local programming environment, using the Python language (version 3.10+) associated with the Django framework, chosen for its organized structure, security and ease of building web applications. The code editor used was Visual Studio Code (VS Code), as it offers features that speed up development, such as integration with terminal, extensions, and version control.

To manage the project's dependencies, the requirements.txt file was used, which brings together all the libraries necessary for the execution of the system. Among them, the Qrcode library stands out, used to generate the identification codes of the coffee lots.

The database used was PostgreSQL, due to its stability, performance, and easy integration with Django. The system was initially tested in a local environment and later deployed on the Render platform, ensuring public access to the system for project evaluation and validation purposes.

3.4 DATABASE

For the storage of data from the RastreCoffee system, the PostgreSQL database was used, chosen because it is a free, stable technology and compatible with web projects based on the Django framework. PostgreSQL was configured to store information related to the coffee lots registered in the system, allowing organization and quick access to the records.

3.5 SYSTEM FEATURES

The RastreCoffee system was developed with a focus on simplicity and usability, so that any rural producer with basic access to the internet can use it. The main features implemented were:

- Lot registration: allows you to register coffee lots with information such as production stage, dates and observations;
- QR Code generation: automatically, for each registered lot, an exclusive QR Code is generated that directs to the information page of that lot;
- Public consultation of information: by scanning the QR Code with a cell phone, the consumer can view the batch data quickly and transparently.

3.6 TESTING PROCESS

After the implementation of the system's functionalities, local tests were carried out to ensure the correct functioning of each stage of RastreCoffee. The tests focused on the following points:

- Batch registration: verification of the correct storage of information in the database;
- QR Code generation: confirmation that each QR Code generated correctly directed to the lot's information page;
- Reading via mobile devices: tests carried out using different smartphones to evaluate the readability of the QR Code and the speed of access to the system;
- System accessibility: verification of the interface, with a focus on clarity of information and intuitive navigation;
- Basic performance: analysis of page response time and validation of route operation.

Tests were carried out manually during development, with simulations made using fictitious data. After validating the operation in the local environment, the system was deployed on the Render platform for additional tests in a web environment. Before presenting the application as the final result of this study, it was necessary to perform these tests to ensure that it was accessible and functioning properly.

3.7 ETHICAL ASPECTS

This study was developed using exclusively hypothetical data, without involving human subjects, interviews or collection of sensitive information. Thus, there was no exposure of the

identity of rural producers, properties or any real personal data. The use of fictitious information allowed the representation of the productive reality of a small family property in an ethical and responsible way, without the need for submission to the Research Ethics Committee. Thus, the development of the RastreCoffee system respected the ethical principles of academic research, preserving the integrity and methodological conformity of the work.

4 RESULTS AND DISCUSSION

4.1 SYSTEM OVERVIEW

The RastreCoffee system was developed with a focus on simplicity, accessibility and practical functionality to meet the context of family farming. Its operation is based on three main steps: registration of coffee lots, automatic generation of QR Codes and public consultation of traceability information by reading these codes.

Figure 1

Source: The authors (2025).

4.2 LOT REGISTRATION

During the tests carried out, the registration form made it possible to record essential information about the coffee lots, such as identification, dates of the production stages and observations. When sending the data, the information was correctly stored in the PostgreSQL database through Django's ORM, proving the integrity of the system's registration flow.
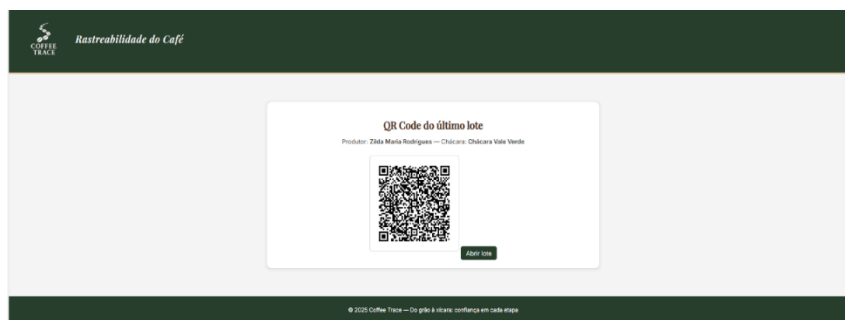
Figure 2

Source: The authors (2025).

4.3 QR CODE GENERATION

The generation of QR Codes occurred automatically with each new registration. The codes were created using the Qrcode library and associated with each registered lot. During the tests, the QR Codes were successfully read on mobile devices, proving their operation and practical accessibility.

Figure 3

Source: The authors (2025).

4.4 PUBLIC CONSULTATION PAGE

By scanning the QR Code, the user was directed to the lot information page in the system. Public access to traceability data made it possible to view information such as the production process, dates and observations of the batch, demonstrating transparency and easy understanding for the final consumer.

Figure 4
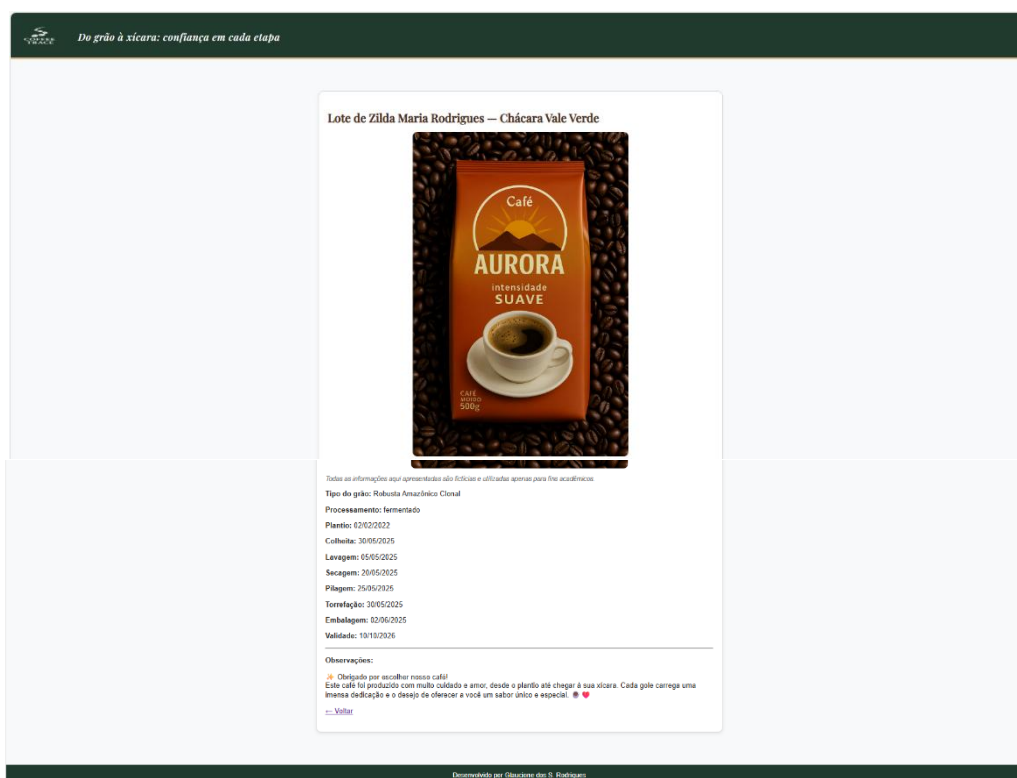
Source: The authors (2025).

4.5 DISCUSSION OF RESULTS

The results obtained demonstrate that the RastreCoffee system meets the proposed objective of providing simple and functional digital traceability for small coffee producers. Its operation proved to be viable in a web environment, with an intuitive interface and compatible with mobile devices. Despite its limitations, such as the need for an internet connection and the absence of more advanced functions, the system has potential for practical use and future improvements.

Figure 5

Source: The authors (2025).

5 FINAL CONSIDERATIONS OR CONCLUSION

The present project aimed to develop a simple and accessible traceability system for the coffee production chain, using QR Code as a digital identification tool. The RastreCoffee system was designed to serve mainly small rural producers, who often do not have access to complex or high-cost technological solutions. Based on the results obtained, it was found that traceability can be applied in a practical and functional way even in family farming contexts, contributing to transparency, product valuation and strengthening of consumer confidence.

The developed system demonstrated technical feasibility by allowing the registration of coffee lots, automatic generation of QR Codes and public consultation of information through a web interface. These features allow any consumer, when scanning the code with a mobile device, to have access to the product's history quickly and objectively. In this way, it was possible to prove that traceability does not need to be limited to large producers or cooperatives, and can be adapted to the reality of small properties with simplicity and low operating costs.

In addition to the technological aspect, the project also highlights the importance of digital inclusion in the field, promoting the gradual adoption of tools that help in the management of agricultural production. The implementation of RastreCoffee reinforces the idea that accessible technological solutions can contribute to the professionalization and competitiveness of small producers, expanding their opportunities for insertion in more demanding markets and connected to good production practices.

Despite the positive results, it is recognized that the system has limitations, such as the dependence on an internet connection to access information and the absence of advanced modules for analysis or logistics tracking. As a suggestion for future projects, it is recommended to expand the system with new functionalities, such as user control,

management reports, integration with IoT devices, and complete traceability via blockchain to ensure greater security and immutability of data.

It is concluded that RastreCoffee achieved its objective by demonstrating the applicability of a technological solution aimed at traceability in family coffee farming. The project showed that, even with limited resources, it is possible to develop useful and functional digital tools, contributing to the advancement of digital agriculture and the strengthening of coffee production in Rondônia.

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