PRODUCT TRACEABILITY SYSTEM FOR THE SUGAR-ENERGY INDUSTRY USING BLOCKCHAIN TECHNOLOGY

Inácio Henrique Yano (Embrapa Agricultura Digital)

Alexandre de Castro (Embrapa Agricultura Digital)

Mariana Abdalla Granelli (Usina Granelli)

Mariana Lopes de Carvalho (Embrapa Agricultura Digital)

Fábio César da Silva (Embrapa Agricultura Digital)

Information on product characteristics, such as nutritional value, target audience, method of use, the way in which they were produced, absence of pesticides, among others, as well as their traceability and origin of the raw materials used in their production can to add value and help in their commercialization, especially for more demanding markets, which would even be willing to pay more for these products.

In relation to traceability, some consumer market niches seek in the certification of origin the desired quality and uniformity, these same groups or others also seek information on sustainability in the production of raw materials and in the production processes. In this sense, computerized systems that facilitate access to this information bring good managerial and commercial returns.

Recently, blockchain technology has emerged for recording transactions, which became well known with the advent of cryptocurrencies, but which can be used for a multitude of applications. Due to its security mechanisms, in particular, those related to the immutability of data, it can be very useful for making information available to large consumer audiences, providing confidence and ease of tracking in case of need. For this reason, a technical cooperation agreement between Embrapa, Coplacana and Usina Granelli was signed for the development of a product traceability system for the sugar-energy industry using this technology.

Key words: Brown Sugar, Demerara Sugar, Certificate of Origin, Ethereum, Sustainability.

1. Introduction

In recent decades, we have witnessed changes in the food production industry, either through the adoption of new procedures or due to new technological devices. Nowadays, information about products and their production processes printed on packaging is a way to add value to the final price or to conquer more demanding markets.

There is a lot of information about products and their characteristics on the packaging, such as nutritional value, the form of use, production procedures, and the absence of pesticides, among others (DE ALICINIO et al., 2021). Another valuable piece of information is the product traceability, such as its origin, the path that the product and its raw materials and inputs took until they were produced or marketed, among other information.

Traceability can add value in two main ways, either through certification of origin or sustainability issues. The origin of the product, when linked to a country, producing region, or brand of industry, recognized as having quality and uniformity valued by a specific audience, can add considerable value to the product (DE FREITAS MOURA and BUENO, 2018). Regarding sustainability, in recent years, due to the problem of climate change, knowledge about the origin of the product and its industrial procedures are relevant to add value and open doors to demanding markets. These demanding markets refuse products whose production is related to deforestation, pollution, piracy, and slavery or child labor (SANTOS and MARTINIUK, 2020).

Recently a new technology for transaction records, called blockchain, has emerged. This technology has the characteristic of data immutability, which provides greater security to information systems, and is usable in diverse applications. In a digital universe, where all information needs to be available at all times and safe against fraud, the possibility of using blockchain technology in traceability systems is very promising.

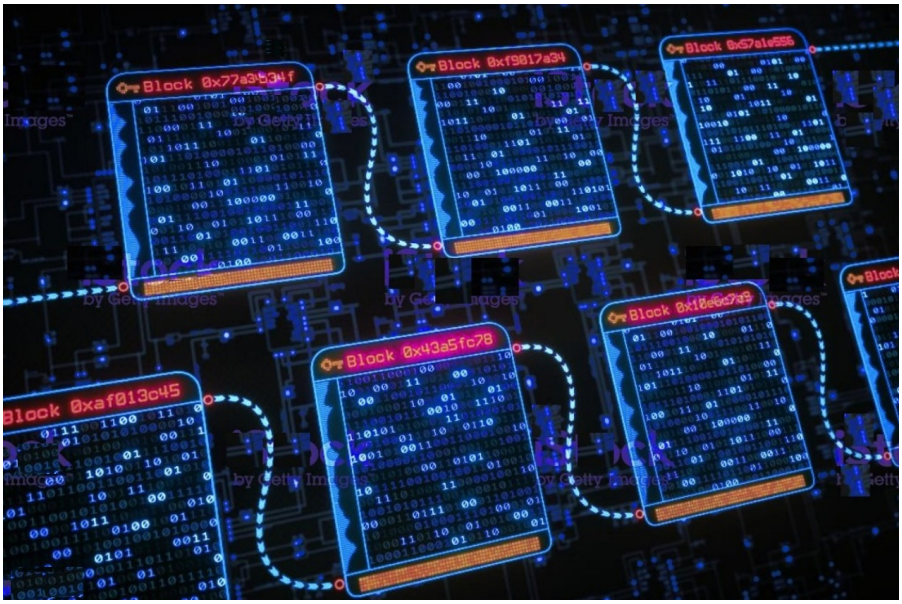
The Sugarcane Planters' Cooperative of the State of São Paulo (Coplacana) understanding of the importance of blockchain technology could provide to the businesses of its associates brought Granelli Mills, one of its associates, to use this technology in the traceability of its products for a pilot project with the Brazilian Agricultural Research Corporation (Embrapa), through a technical cooperation agreement. Thus, this work aims to report the traceability system implementation for brown sugar and demerara sugar, using blockchain technology to guarantee the integrity of quality data, production processes, and origin of sugarcane, its most important raw material.

2. Blockchain Technology

The first description of blockchain technology occurred in the work of NAKAMOTO (2008). Blockchain is a chain of sequentially linked blocks, as illustrated in Figure 1. Data immutability occurs in the way the blocks are constructed, with the current block's content formed by the data to be stored together with the hash[1] code of the previous block. The hash code is a digital signature generated by a hash function to ensure the integrity of the data of each block of the blockchain chain. As the content of the current block stores the current's data and the hash code of the previous block, tampering with the data of a given block would have implications for the hash code of that block, as well as for all subsequent blocks, making a fraud almost impossible to be fulfilled.

This property guarantees the integrity and immutability of the records stored on the blockchain. Blockchain also has other security features, such as being a distributed network and not having a single point of failure. These were the reason for choosing blockchain technology to implement cryptocurrencies such as Bitcoin. However, the possibilities of using blockchain technology go far beyond cryptocurrencies. Blockchain is in most diverse applications, for example, supply chain, asset traceability, e-commerce, and customs clearance.

Figure 1 - Blockchain



Source: Adapted from iSock[2] (2022)

1 Hash code is a fixed-length string generated from a hash function (LEITE, 2018).
2 https://www.istockphoto.com/br/foto/blockchain-tecnologia-conceito-m%C3%BAltiplo-gm913016488-251338970

A valuable feature of blockchain networks are the smart contracts, which are codes with rules, similar to computer programs, that act autonomously, that is, without human intervention, as certain events happen. For example, before making a sale, it is checked whether the product is in stock, and if so, the buyer's debit, the seller's credit, and the stock write-off are fulfilled automatically. Smart contracts are stored on the blockchain network and facilitate the implementation of rules for the most diverse applications (YANO. 2020).

3. Granelli Mills

Granelli Mills was founded in 1988 to produce cachaça. Located in the municipality of Charqueada/SP, located at "Latitude":-22.568400831908765, "Longitude":-47.69026106042742 (Figure 2). It currently produces, in addition to cachaça: brown sugar, demerara sugar, VHP sugar, biomass, ethanol, molasses, and syrup, among other products.

To consolidate itself as an ESG (Environmental, Social, and Corporate Governance) compliant industry. Thus, Granelli Mills:

1) maintains permanent preservation areas and fire-fighting teams;

2) works in soil preservation;

3) has a waste treatment policy, with fertigation and composting of residues. The residues not used on the property are sold or donated, always with the correct destination, whether toxic or non-toxic residues;

4) has a water treatment station to reduce the capture of water from the environment;

5) uses biological control to control pests and diseases, as they are less aggressive to the environment;

6) produces all the energy needed to run the plant, selling the surplus to dealerships;

7) is a socially conscious company concerned with the income and living conditions of the populations surrounding the plant, privileging local labor to work in its facilities.

Nowadays, sustainability has great importance. Because of this, Granelli Mills aimed to develop, with Embrapa, a system to disseminate information on the origin of raw materials, production processes, product quality, and sustainable and socially fair practices and add value to its products. Another aim of this project is the strengthening of the Granelli brand.

Figura 2 - Granelli Mills

Source: Provided by Granelli Mills[3] (2022)

The first product chosen for the tracking system was brown sugar (Figure 3) because of its higher prices. Some bad producers also fake brown sugar, harming consumers, and it is a product intended for consumers who are more conscious about their food and concerned with the type of product they are consuming. There is still a concern if the production was carried out respecting the environmental and labor legislation.

Figure 3 - Brown Sugar

Source: Provided by Granelli Mills[2] (2022)

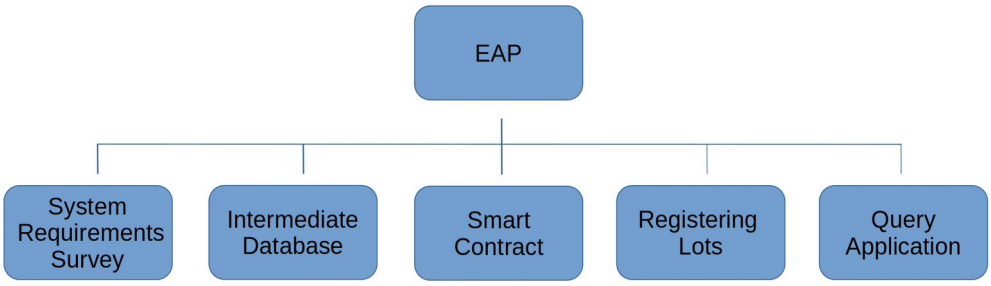
3 https://usinagranelli.com.br

4. Traceability System

4.1 System Development

For the development of this traceability system, five main activities were identified, according to the Work Breakdown Structure (WBS) of Figure 4, namely: System Requirements Survey, Creation of the Intermediate Database, Development of the Smart Contract for Blockchain Application, the Interface for Registering Lots of Products and an Query Application via QRCode of Product Information.

Figure 4 - Work Breakdown Structure (WBS)



Source: Authors themselves

In the System Requirements Survey, there was a concern that Granelli Mills provides all data to the traceability system. The data is on an ERP[4] database of the plant. Due to the General Data Protection Law (GDPL), the Granelli Mills could only make available part of the information of interest to it and its suppliers. Thus it was necessary to create an Intermediate Database, represented by the second activity of the WBS.

The blockchain network chosen for the development of this system was the private Ethereum blockchain network (ETHEREUM PROJECT, 2018) due to the ease of implementing smart contracts, which in this system was limited to recording product data and the origin of raw material. Regarding the third activity of the WBS. Being a private network, only companies that participate in the production and marketing process can access the network, increasing the security and performance of the system.

The fourth activity refers to an interface for the plant to record data on the blockchain, which would be the last production process before packaging. For consumer convenience, the query for the information page seeks a QR code on the brown sugar or demerara sugar packaging (Figure 5). Just by approaching the smartphone's QR code reader. The page containing product information and traceability is displayed.

4 Enterprise Resource Planning (ERP) or integrated management system is a system that allows easy access to information to perform analysis, control costs, increase productivity, and predict trends.

The fifth activity is the consultation page development about the products and the origin of the raw material. In this activity, the hash code of the block will compose the URL of the consultation page, which contains the information of the specific batch. In this implementation, the hash code has 64 characters. In this system, the data generation process is centralized. But the consultation and consequently the conference of the data presented is decentralized and carried out from any smartphone at any point of sale. Thus, if tampering happens, there would be a modification in the hash code, and the page would no longer be displayed.

Figure 5 - Brown Sugar and Demerara Sugar in 1 Kg Pack

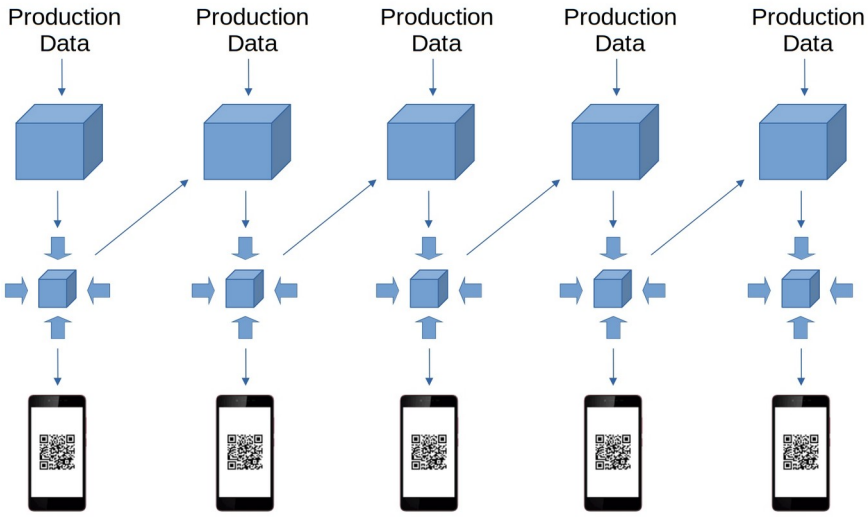
Source: Provided by Granelli Mills[2] (2022)

4.1 System Data Flow

Figure 6 shows the system's data flow over several days of brown sugar production. The production sequence of Figure 6 shows the blocks on the blockchain that stores the production data and the hash code of the previous block. The recording process generates the hash code of the following block, which will be part of the URL of the consultant page. Every hash code will be part of the calculation of the hash code of the next production. This process repeats along the chain successively. This procedure of using the hash code of the previous block in the calculation of the hash code of the following block makes changes impossible in the blockchain. Any change in the data of any block of the chain will modify all the following

hash codes, which would be easily noticed and, thus, conferring the property of immutability of blockchain data.

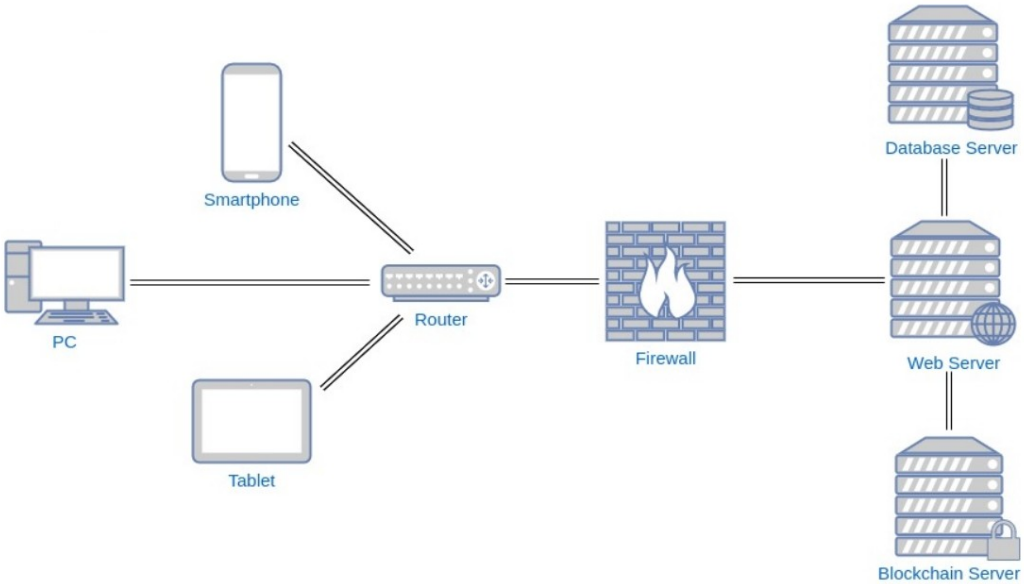
Figure 6 - System Data Flow



Source: Authors themselves

Once implemented, the system's network diagram will consist of the equipment and services shown in Figure 7. On the right side of the router is the Embrapa Datacenter equipment, with the webserver that contains the data insertion applications in the database intermediary and on the blockchain server. On the left side of the router would be Granelli Mills, responsible for managing and transferring data in the traceability system, and consumers who would consult product information and origin of raw materials from any device, mainly smartphones.

Figure 7 - Network Diagram

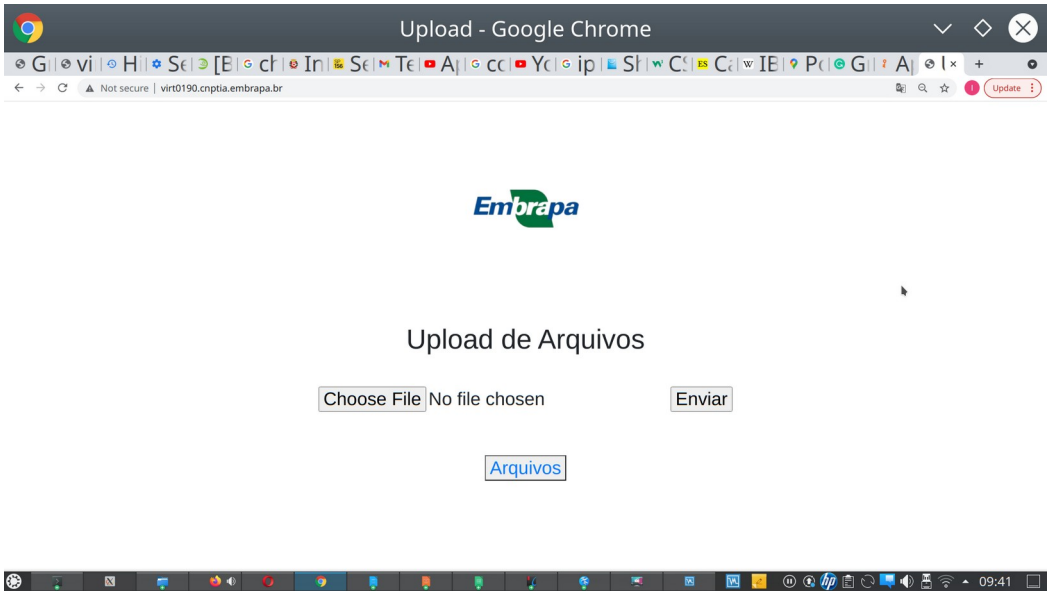


Source: Authors themselves

5. Results

The result of the development of this traceability system is the query pages individualized by batch. The individuality is guaranteed by the unique hash code for each batch and, consequently, for each URL. Figure 8 shows the interface used by Granelli Mills to upload data to the system. Figure 9 shows the beginning of the consultation page, and in the lower-left corner it is possible to see the same screen presented on a smartphone screen.

Figure 8 - Data Upload Page in the Traceability System



Source: Authors themselves

Figure 9 - Granelli Mills Brown Sugar Page

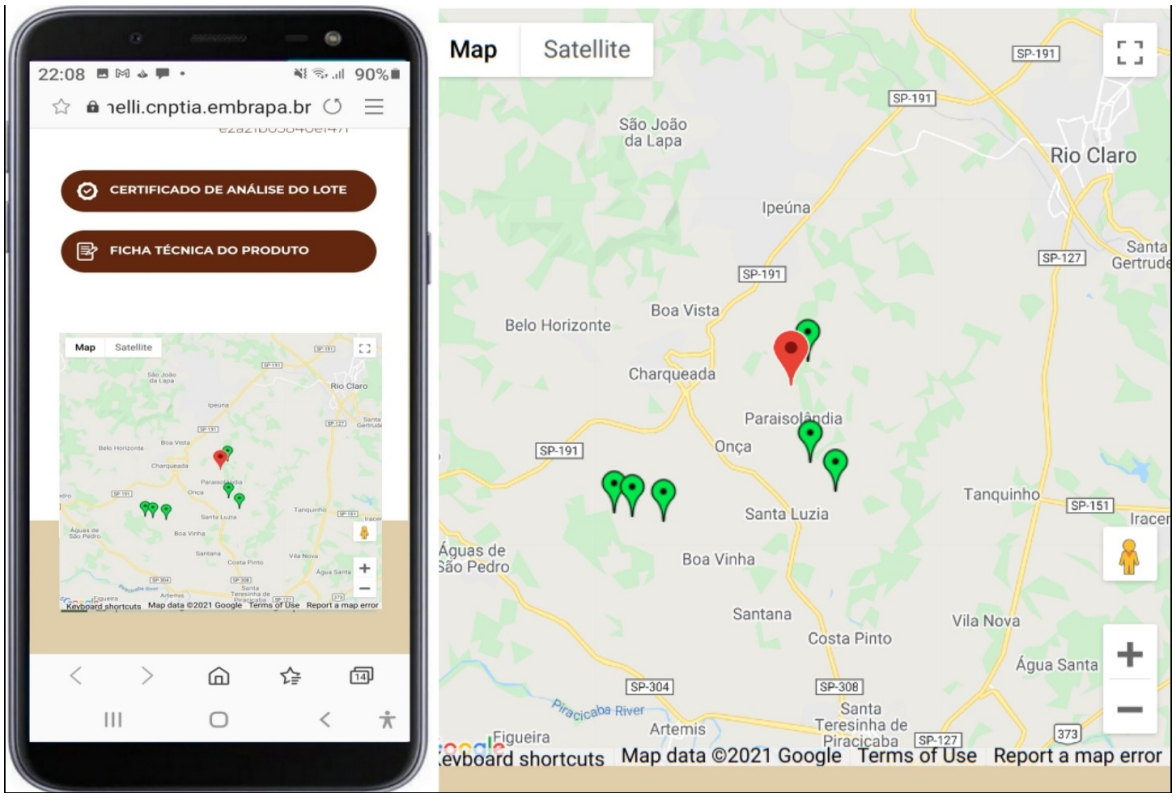
Source: Authors themselves

Figure 9 presents on its first page some information about the product, with screens about the production process of brown sugar production, information about the traceability system, through a promotional video, which explains the role of blockchain to ensure the integrity of the data presented. The system also displays technical information about the product, such as chemical composition, nutritional information, and target audience.

For the most demanding consumers about product quality, the system presents the Batch Analysis Certificate (ANNEX 1), which attests to the quality of the product in terms of color, percentage by mass of sucrose, and moisture, in addition to microbiological analyses. This document comes with the identification and signature of the responsible chemist.

The issue of raw material traceability can be seen in Figure 10, which shows the farms identified by green-colored pins that supplied sugarcane for the lots specified on the brown sugar or demerara sugar packaging. Granelli Mills appears on the map highlighted with the red color pin. Through this map, the consumer could know that sugarcane did not have its origin in areas of recent deforestation, mainly in the Amazon forest.

Figure 10 - Sugarcane Traceability Screen



Source: Authors themselves

6. Conclusion

Consumers' need for information about the products they buy is growing every year. Whether out of concern for their own health, for humanitarian reasons or, above all, for reasons of sustainability, the presentation of this information can be fundamental to competing in current markets and entering new ones, especially those whose consumers have greater purchasing power and opinion.

Therefore, systems that provide specific information on ready-to-sell production batches offer greater security and consumer interest, as they can be quickly tracked and recovered in the event of problems. In addition, the use of technologies that ensure greater data integrity, such as blockchain, further increases reliability for consumers.

In this work, a successful case of using blockchain technology to track products from the sugar-energy industry was presented. As a continuation of this project, it is intended to develop a system to record information from Granelli Mills that is sent to the RenovaBio program. In this program, decarbonization credits (CBIOs) are generated for each ton of less carbon released into the atmosphere at the expense of fossil fuels when biofuels are used; these CBIOs can then be traded by those who need to offset their carbon dioxide emissions (GRASSI, 2019). The goal of this new part of the technical cooperation project is also to store the information sent to the Ministry of Mines and Energy integrally and reliably on a blockchain.

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ANNEX 1

Informações Gerais

Produto	Açúcar Cristal - Mascavo	**Lote**	18102020
Data da Produção	10/18/2020	**Validade**	**2 anos**

Analise Físico Química

Parâmetros	LIMITES	UNIDADE DE MEDIDA	Resultado
Cor Icumsa	< 23.000	U.I.	8,700
Pol	< 92,0	°Z	91.17
Umidade	< 3,00	%	1.04

Analise Microbiológicas

Parâmetros	LIMITES	Resultado
Salmonella	Ausente sp/25g	Ausente em 25 g
Coliforme Totais e Termotolerantes	Máx. 100 UFC/g	Ausente

Aprovado x Sim ☐ Não

Analista Responsável

Fazenda São Benedito, S/N, Paraisolândia - Charqueada - São Paulo - Brasil - CEP: 13515 000 - Caixa Postal 08
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