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A Prototype of Dextran Content Record System in Sugar and Alcohol Production Using Blockchain Technology

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ABSTRACT

Dextran is a polysaccharide produced by bacteria of the genus Leuconostoc spp, which causes loss of sucrose and raises sugar and alcohol manufacturing costs, as well as reducing its quality. Therefore, it is important to control the proliferation of this bacterium, both in the sugarcane field and in agroindustry. In the field should be observed, the length of stay between cutting and transport to industry, the presence of impurities, among other factors. In industry, long storage periods should be avoided, as well as taking care of cleaning and asepsis of the mills and broth treatment tanks. The objective of this work is to record dextran content using blockchain technology because it is a distributed database suitable for applications such as this, which will track the dextran content from the sugarcane field to the production of sugar and alcohol in the industry. A blockchain database is very secure against tampering, which is another advantage of this solution.

Keywords: Ethereum, Smart Contract, Sugarcane.

1. Introduction

Dextrans are a quality parameter for sugarcane, as their presence indicates that there has been deterioration of the raw material at harvest or processing. It is a class of polysaccharides produced by strains of the genus Leuconostoc spp. Although not harmful to human health, dextrans cause problems in the sugar and alcohol industry due to the reduction in sucrose consumed by bacteria, the change in polarization, the increase in lime consumption, the increase in the viscosity of the juice and the reduction in the transfer of sugar heat. Dextrans may decrease the quality of sugar as they may impair the crystallization process of sugar and cause the elongation of refined sugar crystal (Aquino, 2008; Sartori et al., 2015; Silva Neto et al., 2011) (Figure 1).

Dextran formation can occur in tillage, cutting and industrial processing, so it is necessary to avoid and control contamination by the microorganisms that produce it. In farming, insect damage (such as the sugarcane borer), burning or improper adjustment of the harvester favor the development of bacteria, which is present from the soil. Other factors that increase contamination are elevated temperature and humidity, contact of harvested sugarcane with impurities or mud formed by rainfall shortly before harvest, the long waiting time between harvest and transport to the mill, among other factors. In agroindustry, there is usually a stock (yard) where the incoming raw material is on hold, this is necessary due to the irregularity in the delivery times of the sugarcane, this waiting time should not exceed 24 hours, at risk of deterioration of the raw material, disinfection of the mills and fermentation barrels of sugarcane juice should also be made (Oliveira et al., 2002; Naves et al., 2010).

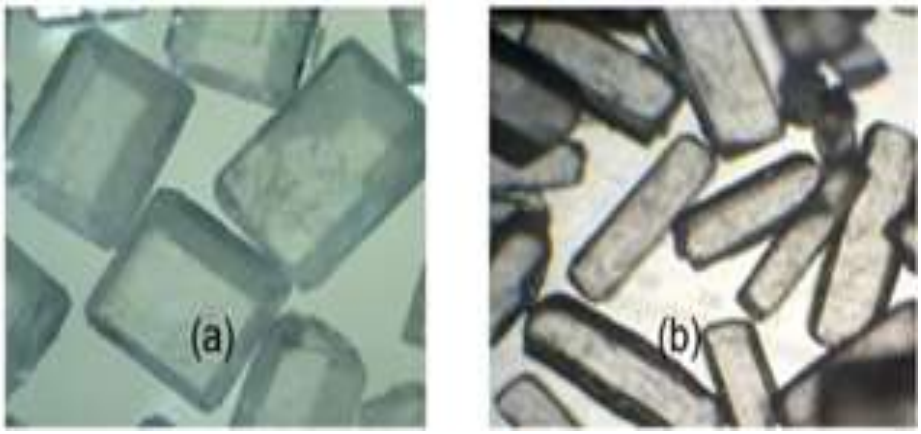

Figure 1. Good quality sugar crystal (a) and sugar crystal elongated by the presence of Dextrana (b), adapted from Albuquerque (2019)

The sugarcane processing monitoring from the field and during industrial production is of fundamental importance for the control and reduction of the influence of microorganisms on sugarcane production, so the record of dextran contents can help in the evaluation of contamination and reduction of losses in the production processes, as well as in the quality assurance of the products for the trade. This work presents a prototype dextran grade record system using blockchain technology. The choice of this technology was due to the fact that it is a secure database against tampering, having also the advantage of being distributed (Aniello et al., 2017), which would facilitate the recording of dextran contents in different places and times, that is, from the field, through the processes, agribusiness, and may even accompany the product to the final consumer.

The blockchain is a decentralized and distributed system to share immutable data, which stores records of assets and transactions within blocks of data in a peer-to-peer network. The blockchain uses encryption for authentication, data integrity, and hash creation. Besides the data, each block also contains the hash of the previous block, forming a chain. The blocks are timestamped and validated by a process called mining. In the mining process, each transaction is shared, verified, and validated by consensus of the majority of a group of mining nodes. After validation, the block becomes immutable, i.e., it can never be deleted or changed (Khan & Salah, 2018).

The prototype, at this stage, only contemplates the phases of the sugarcane industry processes, which is the center of the sugarcane chain. But it would already allow identifying dextran content with higher than desirable concentrations, which could compromise the quality of the sugar and alcohol to be produced. These findings would alert the operators to the need for corrective maintenance or preventive for new production cycles. In addition to explaining the possible causes of deviations in the quality of the products produced.

2. Material and Methods

In this first study, the prototype was developed to record the dextran content on the five main sugarcane production stages, as shown in Figure 2. The process begins with the Harvest procedure, which occurs in the field. The sugarcane harvested goes to the industry, where it is received to pass through the Extraction procedure to broth extraction. The broth is chemically treated and decanted in the Treatment procedure. The broth decanted can be used for sugar production in the Concentration procedure or can be used for alcohol production in the Fermentation procedure. Sugar and alcohol go out of the industry to the market.

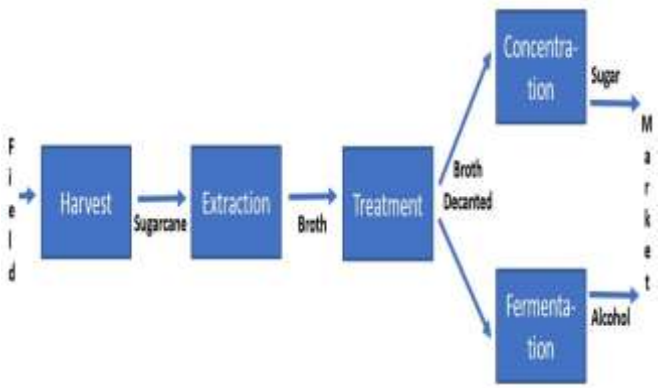

Figure 2. Sugarcane Industry Processes Simplified in Five Stages

In these five production stages, the dextran contents will be recorded, as well as the date on which the sampling occurred. The prototype was built as a smart contract written in Solidity 0.4.2 (Panescu & Manta, 2018), which is very similar to Java, Python, and other programming languages in the Remix Development Environment (IDE Remix) (Karataş, 2018; Silva, 2019), for Ethereum Blockchain Networks (Valenta & Sandner, 2017; Yano, 2019). Figure 3 shows the DextranTrack.sol smart contract in IDE Remix's "Compile" tab for smart contract compilation. The left side of Figure 3 shows the smart contract code, with the Solidity 0.4.2 language version, and the variables used to receive dextran content records in parts per million (ppm) and per batch, plus date information of sampling.

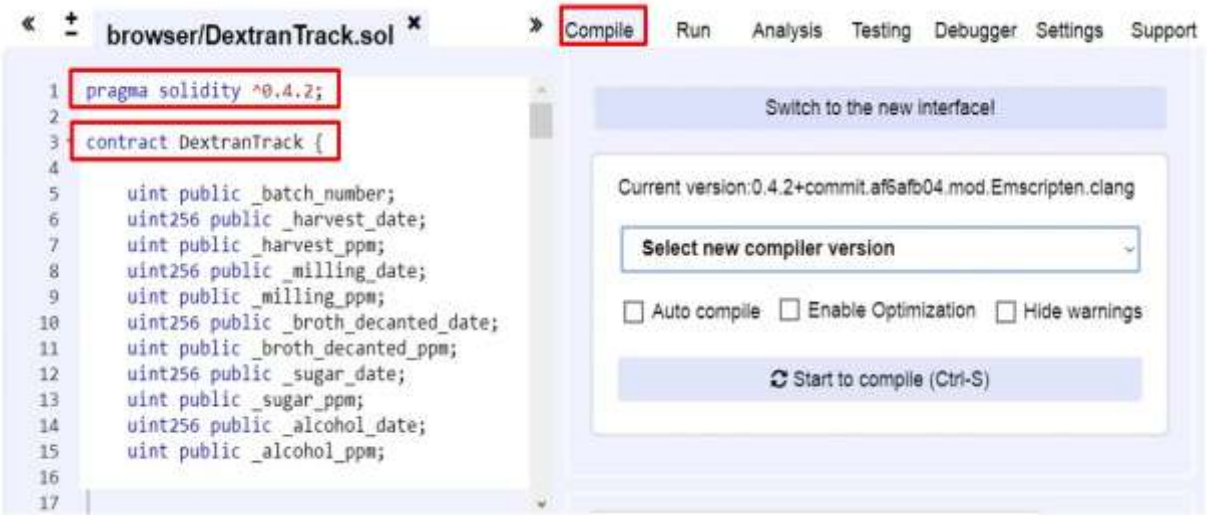

Figure 3. Remix development environment (Karataş, 2018, Silva, 2019)

To set values to variables and record data into the blockchain, each variable and each procedure in the sugarcane industry processes has a corresponding function in the smart contract. The left side of Figure 4 is an example of a function to set batch number this number is an identifier of the sugarcane batches created for sugarcane processing. After the setting of all variable values of the procedure, the corresponding function of this procedure is able for execution. The left side of Figure 5 shows the code of the Harvest procedure. The execution of the procedures will store data in a structure shown on the left side of Figure 6, which can be retrieved whenever is needed. There are four other functions: Extraction for broth extraction, Treatment for broth clarified and decanted, Concentration for sugar production, and Fermentation for alcohol production.

Figure 4. Function to set the batch number

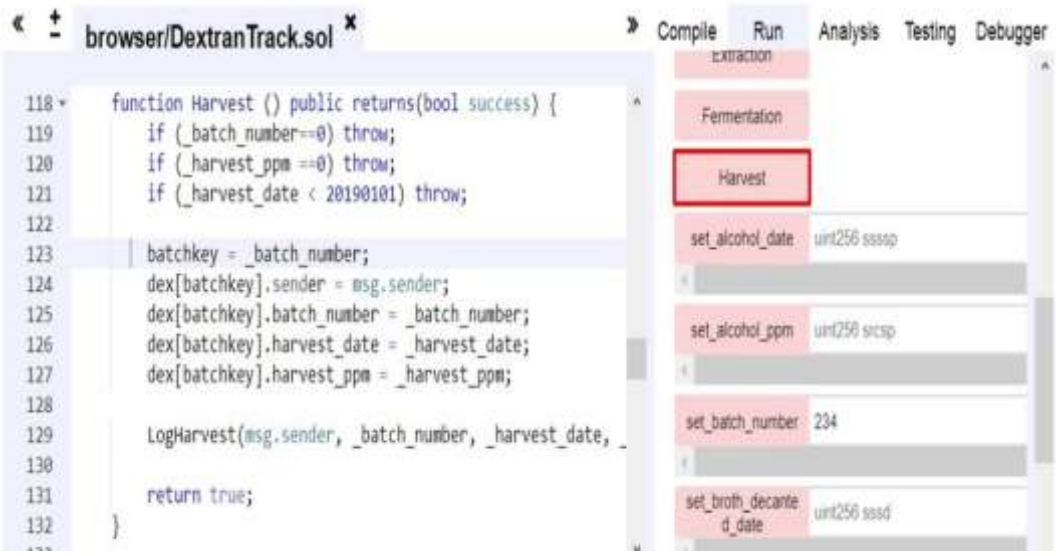

Figure 5. Function to record harvest data

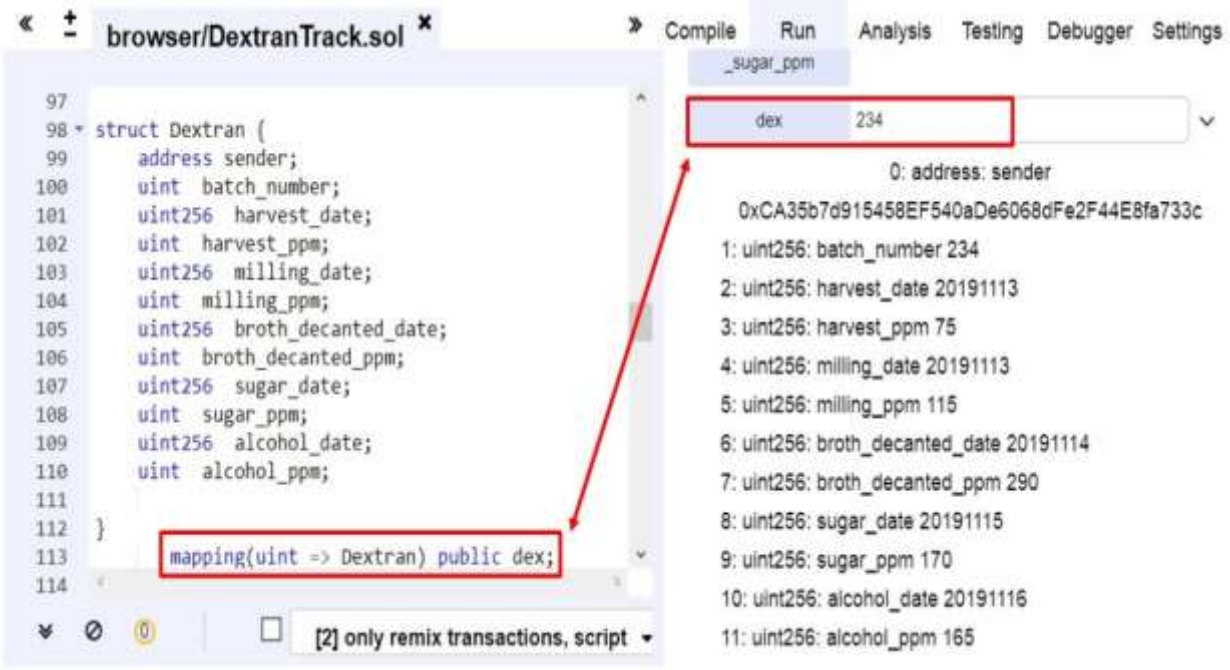

Figure 6. Queries the recorded data for batch 234

3. Results

The interface to execute the smart contract is the IDE Remix's "Run" tab, shown in Figure 7. After deployed the smart contract is ready for simulations and tests. The IDE Remix provides five accounts, each one starts with a balance of 100 ether for accounting purposes.

IDE Remix creates a button used for an interface for each function developed. The right side of Figure 4 shows the button for the set_batch_number function for setting values to the batch number variable. Figure 4 shows an example of recording batch number 234. The right side of Figure 5 shows the button of the Harvest procedure. By clicking in this button the batch number, date of sampling, dextran content and the blockchain user account that is responsible for the operation (msg.sender), this information, obtained from Ethereum Blockchain network transactions, will be stored into the blockchain database.

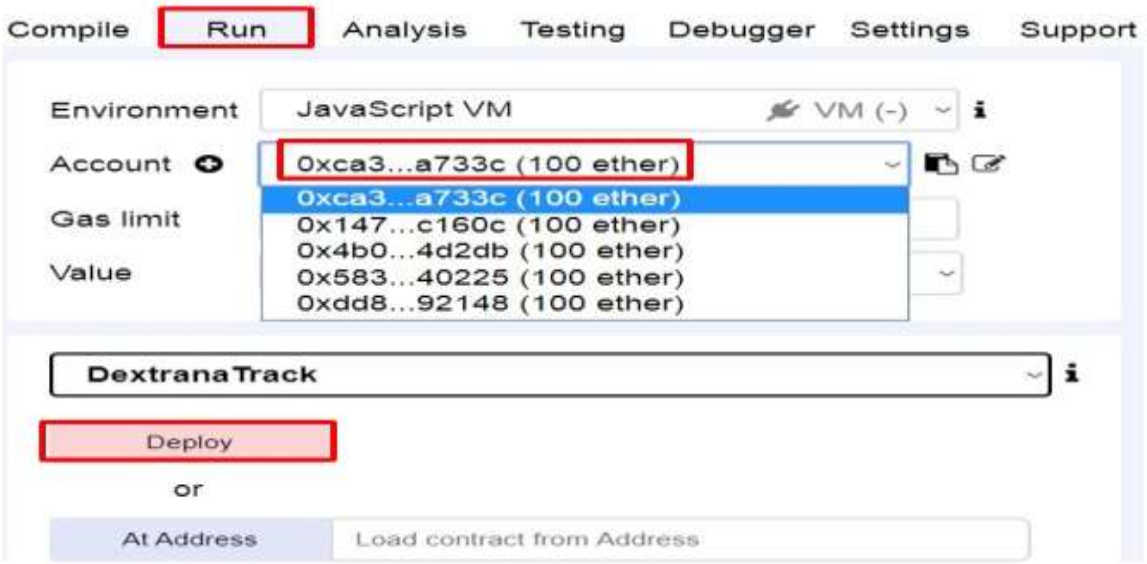

Figure 7. IDE Remix's "Run" tab

In the same way of recording Harvest data, data about Extraction, Treatment, Concentration, and Fermentation stages will be recorded as these production steps have been completed.

The batch number is the key to query all recorded data. For this purpose, there is a mapping between the batch number and the Dextran struct, which associates the data structure with the batch number. The right side of Figure 6 shows the result of querying batch 234 data after completed all production steps of sugarcane processing.

4. Conclusions

The objective of this work was to develop a prototype to record dextran levels in sugarcane production. Since it is a prototype, it does not contain all the links in the sugarcane production chain but contains data from the agroindustry production stages, which is the center of the chain and where dextran control can be most effective. This work is also an example of Decentralized Application (DApp) using blockchain technology, due to the security advantages and distributed database that this technology can provide.

In this work, the IDE Remix was the interface to interact with the blockchain framework. But in a real production system, this could be done by IoT, RFID, and other data entry methods. As a continuation of this work, a study to capture soil moisture using IoT as a thin node of the blockchain network will be developed, because there is a relation between mud formation in the field before harvest and high dextran content. Another work to be developed is an application based on Javascript, PHP and shell scripts to retrieve information from the blockchain framework, i.e., without using the Remix interface for this job.

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