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An Approach for Creating a Blockchain Platform for Labeling and Tracing Wines and Spirits

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Abstract. The traceability and labeling of products have been issues faced for decades in various industrial and commercial sectors. One of the most important product categories that require effective traceability and, at the same time, anti-counterfeit labeling are wines and spirits. The ineffective traceability of such products poses extremely serious risks both to the national economy and consumers' health. This paper aims to propose an approach for creating a blockchain traceability and labeling platform in order to ensure the origin, quality and authenticity of wines and spirits. The platform will combine a number of advanced technologies, namely blockchain, anti-counterfeit labels, and smart contracts and sensors, to offer effective traceability at all stages of the supply chain of wines and spirits. The paper starts by presenting the research's background and continues with analyzing the methodological approach for the development of the platform, its functionality, and the expected benefits from its implementation.

Keywords: Traceability, Supply Chain 4.0., Blockchain, Internet of Things, Labeling, Wines, Spirits, Research Project.

1 Introduction

The need for effective traceability in the food and beverage industry has greatly increased in recent years due to the growing consumer awareness for the safety and the quality of products they buy [1]. Traceability can be defined as the ability to track and detect the origin of a product during its production and distribution [2]. The loss of visibility as to the origin of a product can cause significant disruptions in the production and distribution of goods, but also poses serious risks for consumers. More specifically, products that endanger consumers' health may be produced and marketed when they can't be effectively traced at all stages. The same can happen when transporting products along the entire supply chain, either due to deviations from the intended transport conditions (e.g., temperature, humidity) or possibly due to product

sabotage (replacing packaging contents, forgery of labels, etc.). In addition to the negative effects on consumer health, adverse economic consequences may also arise for the producer, and his credibility may be damaged. Therefore, eventually, consumer confidence can be irreparably shaken [3].

According to the World Health Organization, 25-30% of wines and spirits consumed worldwide suffer from some form of deterioration each year. It is characteristic that between 2017 and 2019, 306 mass cases of beverage adulteration with methanol were recorded worldwide, resulting in 7,104 people becoming ill and 1,888 dying [4]. Such a case is stated by Europol, who reported that in March 2017, in Greece, the Economic Crime Unit of the Ministry of Finance discovered two illegal alcohol storage areas. All seized bottles were about to be transported illegally, mainly to Bulgaria, avoiding duties and taxes. Nearly 1,300 liters of adulterated alcohol (vodka and whiskey) were seized, and five people were arrested [5, 6]. Similar illegal trading and adulterations of wines and spirits may occur with a variety of means. Such activities in the economy are enormous as non-effective traceability in the wines and spirits industry results in billions of euros and thousands of jobs being lost every year. In fact, according to the European Union Intellectual Property Office (EUIPO), in the EU, 2.3 billion euros are lost in direct sales each year due to the trading of counterfeit wines and spirits. In addition, 5,681 jobs are lost each year. Overall, however, taking into account the knock-on effect in other sectors, 5.2 billion euros and 31,858 jobs are lost each year [7].

On the other hand, through an effective traceability system, the producer can improve the production quality of his products and reduce or even eliminate the financial damage from the sale of products that do not meet the required specifications. At the same time, the produced products can be transported safely, and the consumer can be able to validate that the product he buys has not undergone any kind of alteration or counterfeiting [8]. Furthermore, an effective traceability system can allow products to be inspected, individually or in batches, so that they can be relatively easily isolated if safety or quality issues arise. Such a system also allows the quick identification of the source of a problem to be addressed immediately and be avoided in the future. Finally, an efficient traceability system provides strong transparency in the production and supply chain, allowing all info related to the supply chain of products to be located at any time [9].

The most common challenge faced when trying to trace products is the incomplete or non-functional labeling they have. The weakness of most labeling systems currently found on food and beverages lies not only in the lack of information on labels but also in their ease of counterfeiting [10]. Most of the labels contain basic information such as the product name, production/expiration dates, origin, and ingredients. In this way, a plethora of data concerning the production and distribution of the product cannot be not visible to consumers [11]. Over the years, various technologies have been applied to deal with these weaknesses of labels. Most of these applications, however, were limited to only creating technologically advanced and non-copyable labels (eg Barcodes, QR codes, RFID tags, NFC tags, Holograms, colorhifft Inks, Embedded images, digital watermarks, invisible printing, watermarks, Chemical and biological tags, microtaggants), without addressing the problem of traceability holistically [12].

The novel aspect of this research is the holistic approach that is followed, combining both advanced technologies and non-copyable labels and integrating them into an effective traceability platform that will help secure the wine supply chain and lead to more efficient operations. In fact, the application of the blockchain technology in the supply chain is relatively new and only during the last three years research studies started to address related issues [1, 13–19]. As for the wine supply chain, that is the focus of our research, to the best of our knowledge, no such research attempt has been made combining the aforementioned advanced technologies and non-copyable labels into a single software solution.

2 Advanced Technologies for Effective Traceability

Advances in technology can enable companies to monitor, in real-time, the conditions, the production, and the distribution of their products through smart sensors via the Internet of Things (IoT) [20]. These sensors are able to record and send events in a secure and inviolable way when aided by the blockchain technology. This technology, which has started to be widely used in many new industrial applications in recent years, can be combined with the technologically advanced labels as well as with smart sensors (location, humidity, temperature, vibration) and smart contracts (self-executing contracts with the terms of the agreement between buyers and sellers) in order to enable wide traceability in the supply chain of food and beverages from their production to their final disposal to consumers [21].

Blockchain can be essentially considered as a seamless distributed digital transaction data chain that is constantly authenticated with each new transaction that is added. This blockchain structure eliminates the possibility of data processing and alteration by third parties while providing data transparency and security for suppliers, distributors, and all counterparties in products' production and supply chain [19]. Blockchain allows the immediate detection of problems or deviations in relation to the specifications and enables the use of quick measures for reducing their impact. At the same time, by collecting information (transactions) from every step in the food and beverage and supply chain, blockchain can offer transparency and protection against the falsification of information on labels and the alteration of products.

Eventually, by combining all the aforementioned advanced technologies into a single functional platform, the consumer will be able to verify the origin and the quality of the goods he buys. Thus, he will be able to find whether the goods suffered any sabotage as well as the point at which it occurred [22]. All these technologies are part of the Industry 4.0 which is the ongoing trend for the automation of traditional manufacturing and industrial practices, using today's technological advances. Additionally, during the last few years, these technologies have started to gain increasing popularity in supply chain activities and have led to the formation of the Supply Chain 4.0. This next-generation supply chain uses advanced technologies such as the Internet of Things (IoT), Blockchain, Big Data Management, etc. in order to achieve more effective and efficient operations within the supply chain.

In the remainder of this paper, the conceptual approach for creating an advanced platform for labeling and traceability of wines and spirits will be presented. The platform will combine a number of advanced technologies, such as blockchain and advanced labels to offer effective traceability at all stages of the supply chain of wine and spirits. The research focuses on wines and spirits as their ineffective traceability poses extremely serious risks both to consumer health and the economy in general.

3 The Blockchain Platform

The need for a clear and safe wines and spirits supply chain led us to the formulation of an approach for creating a platform that enables the end consumer to detect all the information related to each individual wine or spirit he buys while also being able to validate that the product has no type of counterfeit. In other words, the platform will be able to provide reverse control to each counterparty from the producer to the final consumer, presenting all the authentic information related to the product and ensuring faster and safer transactions. Furthermore, the exchange of all information between the different counterparties throughout the supply chain will take place through blockchain technology without compromising privacy and security.

3.1 Platform's Methodology of Development

The methodology proposed to be followed includes two main phases. The first phase is to find and evaluate the requirements of the platform as well as the technologies and methods that will be implemented for the effective traceability of wines and spirits. The second phase concerns the development and testing of the platform in the wine and spirits industry's production and transport companies.

More specifically, during the first phase, wide research needs to be conducted focusing on the inefficient traceability of the wine and spirits supply chain. Advanced methods and technologies that will enable the labeling, identification, and monitoring of each individual bottle along the entire length of the supply chain will also be investigated. At the same time, the methods of integrating blockchain and IoT technologies for data management and sharing will be explored. Afterwards, real scenarios of production and distribution of wines and spirits will be examined, the followed procedures will be recorded, and they will be adapted according to internationally recognized standards. Next, the advanced methods and technologies that are most suitable for implementing the platform will be selected.

In the second phase, all the selected advanced methods and technologies will be integrated into the traceability platform. Finally, the platform will be offered as a BaaS (Blockchain as a Service) service and, before its commercial release, will be tested in production and transportation companies of wine and spirits. Essentially, through the conducted tests, it will be determined whether the platform offers an effective traceability service, while possible weaknesses and failures will be identified and corrected before the platform's final release to the market.

3.2 Platform's Functionality

The blockchain platform, as already stated, is aiming at the effective traceability of wines and spirits. Therefore, internationally recognized standards will be used to identify the products, record the locations, and share data. These standards are effective procedures followed in practice and will effectively manage all data on the platform. In fact, as these standards are universally accepted, they can be used in any kind of product traceability system.

More specifically, to achieve effective traceability, each wine or spirit that needs to be tracked will be recognized by unique codes, allowing access to all data related to its history, use, or location. In addition to identifying this info, the platform will also record all the critical events from the production to the final distribution of the product to consumers. The platform will be able to record all the events of the supply chain of wine and spirits regardless of their origin and the possible inhomogeneities of the entities that will send the events (Fig.1). In addition, all required codes will be recorded on state-of-the-art labels that cannot be reused, counterfeited, or copied. The blockchain database will contain data shared between the cooperating entities (eg producers, distributors, resellers) and data on transactions and verify the authenticity, origin, and possible loss of product quality (Fig.2). In this way, at any time and in a completely safe way, the products will be able to be checked without making the information available for copying or counterfeit to third parties.

The use of smart non-copyable labels and smart sensors is a significant advancement as they will communicate with the platform sending necessary data (e.g., location, temperature, time, shock or validation). Therefore, there is a need for measurements to ensure that the labels and the smart sensors will not be fiddled. Furthermore, as already mentioned, the platform will operate in the blockchain network, which provides increased security against fraudulent attempts. For this reason, advanced blockchain tools and protocols will be implemented into the system, and each stakeholder will have a set of public and private keys. The data will be inserted into the platform only with the combination of the above keys and will be validated each time a change is made. Therefore, third parties aiming to fiddle the data sent to the system will have no access to perform such activities.

Despite the fact that advanced technologies will be implemented for the effective traceability of products, the platform's interface will be user-friendly both for the stakeholders and the end-customers, requiring basic knowledge of web usage and no advanced programming skills. The stakeholders will feed the platform with their data requiring no knowledge of the blockchain technology. Furthermore, the platform will automatically execute the smart contracts and validate the aforementioned data. Finally, the end-customer will only scan the product's advanced label to view and validate the authenticity, quality, and origin of the products, requiring no registration and personal data provision.

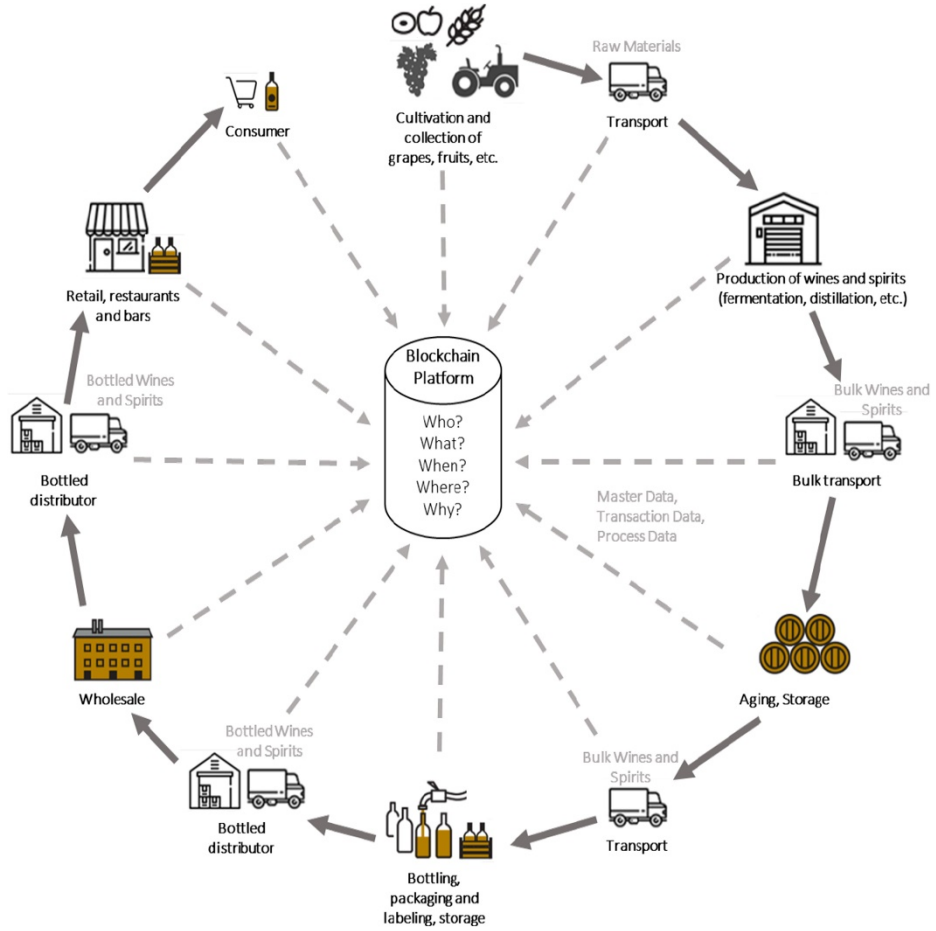


Fig. 1 Blockchain Traceability Platform's Data Collection

Who	What	When	Where	Why
Cultivator	Grape Varieties, Quantities	Harvest Completion Date	Vineyard	Grape Production
Carrier	Vehicles, Boxes of Grapes, Quantities	Boxes Receipt & Delivery Dates	Vineyard - Winery	Transport to Winery
Wine Producer	Wine Varieties, Wine Containers, Lots, Quantities	Wine Production Completion Date	Winery	Wine Production
Carrier	Vehicles, Wine Containers, Lots, Quantities	Container Receipt & Delivery Dates	Winery - Cellar	Transport to Cellar
Ageing Cellar	Barrels, Wine Varieties, Lots, Quantities	Ageing Start & End Dates	Cellar	Aging, Storage
Carrier	Aged Wine Barrels, Lots, Quantities	Barrel Receipt & Delivery Dates	Cellar-Bottler	Transport to a Bottle
Bottler	Bottles, Wine Varieties, Lots, Quantities	Bottling Date	Bottler	Bottling, Packaging, Marking, Storage
Carrier	Boxes with Bottles, Quantities	Boxes Receipt & Delivery Dates	Bottler - Wholesale Warehouse	Transport to Wholesaler
Wholesaler	Boxes with Bottles, Quantities, Orders	Ordering, Receiving & Sending Boxes Dates	Wholesale Warehouse	Retail sale
Carrier	Boxes with Bottles, Quantities	Boxes Receipt & Delivery Dates	Wholesale Warehouse - Retail Stores	Transport to Retail Stores
Retailer	Bottles, Quantities, Orders	Order, Receipt & Shipping of Bottles Dates	Retail Stores or Other Points of Sale	Sale to Consumers
Consumer	Bottles	Bottle Purchase Date	Anywhere	Check of Origin, Quality, Authenticity

Fig. 2. Data Received from Wines and Spirits Supply Chain

3.3 Expected Benefits from the System's Implementation

When successfully developed and implemented in real-life cases, the blockchain platform can offer a plethora of benefits. First of all, it will strengthen the competitiveness, extroversion, and productivity of all parties involved in the wine and spirits

supply chain. Additionally, it will contribute effectively to reducing economic losses and protecting the jobs in Greece and consequently the European Union due to inefficient traceability of food and beverages. The platform may also enhance the efficiency of food and beverage companies, as any deviation from the specifications will be detected directly by the system, and parties will be able to take faster corrective actions.

Moreover, the platform could also serve as a reference point for creating similar software solutions for product traceability. Therefore, through the successful combination of today's technological advances, the platform could be extended and proven to be useful in all supply chain activities. In this way, all parties of the supply chain will be able to work more efficiently, and the consumer will be able to check the origin, quality, and authenticity of each product he buys. This will ultimately increase the participants' trust in the supply chain, proving the products' origins and providing secure supply chain data management.

4 Conclusions

This paper presented an approach for creating a blockchain-based platform for labeling and tracing wines and spirits. The research focused on this specific industry as, according to statistics, it belongs to the five industries with the largest loss of sales due to adulteration and counterfeit and doesn't only cause huge financial losses but also poses very serious risks to the health of consumers. However, the proposed platform can strongly contribute to the creation of a visible and safe wines and spirits supply chain making use of today's state of the art technologies such as blockchain, IoT, and advanced labels.

The key advantages offered by the platform include the protection against data counterfeiting, reduction of production and distribution costs, transparency, holistic control, and finally, the guarantee of authenticity and quality of each individual product. The platform will operate in a decentralized manner and allow the secure sharing of data since it will be offered through the BaaS (Blockchain as a Service) model. In this way, parties involved in the wine and spirits supply chain will have no need for back-end users who need advanced computer skills and powerful servers and avoid expensive setup and maintenance costs.

As it becomes clear, the benefits for society will be significant. In fact, the more stakeholders decide to participate in this effort, the more transparent and safer will the traceability platform become. More specifically, the production, the distribution companies, and the retailers will have the ability to immediately be alerted about any deviations from the planned supply chain operations and take proper actions on time. Finally, the end-customers will have the ability to validate the authenticity, the quality, and the origin of the products they buy.

Having concluded the first step of this research, which focused on the conceptualization of the blockchain labeling and traceability platform, the next phase will concern research methods for integrating blockchain and IoT technologies in the platform. This next step of our research is essential as it will include the requirements

analysis and the specification of the advanced technological solutions that will be integrated into the platform.

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