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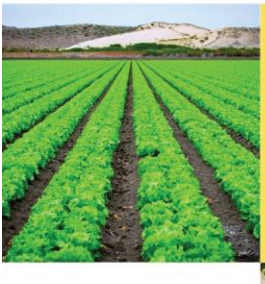

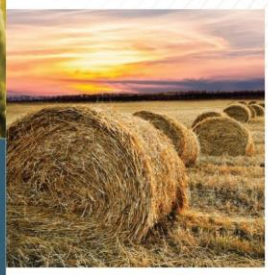


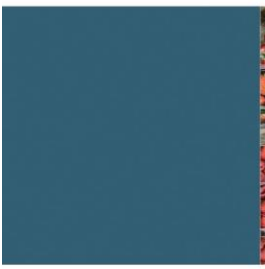


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CONCEPTUAL BLOCKCHAIN MODEL FOR HONEY SUPPLY CHAIN SYSTEM

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Abstract

Increased global demand for honey has encouraged fraud. In order to better monitor the honey supply chain and prevent frauds, in this paper is created a traceability scheme for honey processing and trade in Serbia, based on which a conceptual blockchain model for the honey supply chain system was proposed. This research can contribute to the improvement of the electronic record system designed to ensure the traceability of honey through the proposed blockchain-based conceptual model. The concept covers the monitoring of honey through the stages of production, processing and distribution in order to improve the implementation of good production and processing practices through smart monitoring. Through information and relevant images provided by beekeepers, consumers receive additional information about the origin of honey, which is of great importance for today's consumers.

Key words: Honey supply chain, blockchain, system

Introduction

Honeybee colonies are essential for agriculture and the environment. The great importance of honey and honey products is reflected in its nutritional composition and medicinal properties. Since the eighties of the last century, the production of honey in the world has been constantly increasing. The EU plan is to spend €240 million on national apiculture programs in the EU for the apiculture years 2020-22, which is an increase of 11% compared to the funding available for 2017-19. According to the European Commission pilot study (2022), new bee diseases are appearing, under the influence of intensification of agricultural practices as well as climatic changes and globalisation.

The demand for honey is increasing, especially with the rising demand from consumers and popularity of honey-based pharmaceutical and cosmetic products. It is estimated that this is the fastest growing market for honey. As a consequence of increase in global demand for honey, various frauds appear.

"Honey fraud is a threat to national food security."[1] Great efforts are being made to increase the level of technology used in honey production and packaging. However, practices that can result in the contamination of honey and related products are still used. Furthermore, different formats are used to record the various production, processing and distribution procedures, without any standardization, which makes it impossible to ensure proper product traceability. The absence of standardization prevents or makes product traceability very difficult. This paper proposes a concept based on blockchain technology that can improve the traceability of the honey records.

Honey is mainly traded in spot markets, either by direct sale to consumers or by sale to customers (mead houses or retailers). The high administrative costs of contracting with a large number of small producers encourage contracting with bigger players. In their research (Shrestha et al., 2017) analysed honey value chain in Lamjung District of Nepal and came to know about the horizontal and vertical linkages among the value chain operators. It is spotlighting a relatively short chain from producers and ending in consumers and includes actors like input suppliers and service providers, producers, wholesalers, retailers and consumers. it is insufficient numbers of researches dealing with the analysis of honey supply Serbia. Research by Ignjatijević et al. (2015) pointed that honey sales channels are not sufficiently developed in Serbia.

In the literature, many models based on blockchain technology have been proposed in the function of food supply chain monitoring (Ehsan et al., 2022; Pandey et al., 2022). Rünzel et al. (2021) proposed smart agricultural system that can improves food security and food safety, and reduces honey fraud. Image-based traceability system is built on blockchain technology with pollen signature verification with the help of machine learning algorithms. Image-based traceability of the honey is suggested in the work of He et. al (2018).

In this paper we proposed conceptual Blockchain Model for Honey Supply Chain System for Serbia.

Honey market and honey fraud

The main product of the beekeeping industry is honey. It is very hard, to obtain data on the production of pollen, royal jelly, wax and other related products. China is the biggest producer of honey, with approximate 500.000 tonnes, followed by the EU (near 240.000 tonnes) and Turkey (over 100,000 tonnes) in 2020. Russia and Ukraine participate with 4% each of the Word productions. The EU imports the most honey, scooping up 200,000 tonnes. Main EU honey suppliers are Ukraine (31,1%), China (27,7%) and then Mexico with 8,9% in 2021. This structure will certainly be changed in 2022.

[1] Norberto Garcia, Chairman of the U S Pharmacopeia Expert Panel on Honey Quality and Authenticity (As told to the Economist)

Honey from Serbia is of excellent quality thanks to favourable climatic conditions and diverse flora. Serbia is a relatively small country, so the international market is an important element of a good economy and successful beekeeping production. In order to increase exports, and thereby increase domestic production, in 2007, the Ministry of Agriculture included for the first-time honey among the products that are subject to production subsidies. Beekeeping technology has advanced in the Republic of Serbia, which can be seen from the increase in the number of hives. Until now, the beekeeping area received help from the state for massification, but now it is necessary to take certain measures to help the development of beekeeping as an economic activity. For the further development of this sector, greater placement on foreign markets is needed, which is why both a good reputation of honey and its traceability are needed.

Frauds in production and other honey supply chain processes are different. It is often deliberately labelled and adulterated (dilution of honey using for example corn syrup, with banned chemicals like antibiotics or pesticides etc.). The quality of honey can also deteriorate due to improper technological processes of obtaining, processing and storing it, such as heating at a high temperature, storing in unfavourable conditions, pollution (location of hives in densely urbanized or industrialized zones, including agricultural pesticide use), etc. Furthermore, the practice is to use old and dark combs and/or brood combs for higher acidity and faster aging, use of combs with residual honey from a previous year (possibility of faster fermentation; premature crystallization, contamination of unifloral honeys). The problem of adulteration is not only in adulterated honey but in the export of the methods for adulterating honey.

In “Honeygate” scandal Chinese honey was being transhipped through Germany (and thereby labelled as German honey) and imported to the USA by a number of food suppliers (Graham, 2011; Swaine, 2013). It is interesting to mention that at Apimondia 2019, the prestigious World Beekeeping Congress held in Canada, in the competition for the best honey there was 46% counterfeit honey. “Fake honey” has presented a challenge for governments and reputational concerns for some of the biggest honey producers.

Large retail chains procure honey from large buyers. Often, such honey is a mixture of honey from several producers, so consumers who want varietal honey from a well-known beekeeper will not go to the supermarket, but will look for it at the local apiary. Beekeepers must try to convince consumers they have a clean, healthy, natural product.

There are different types of forgeries. Some can be detected based on the analysis of basic physicochemical parameters according to the rulebook, while the detection of some others requires more complex analyzes and more expensive equipment. There is no universal method for detecting counterfeits. We can only talk about the methodology, the combination of several methods and the comprehensive analysis of the results obtained.

As clearly described in the Apimondia Statement on Honey Fraud (Apimondia, 2020), the preservation of honey quality and purity becomes absolutely essential for the sustainability of the honey chain whose foundation begins with beekeepers. Apiculture programmes in EU for 2020-22 were approved by EU Implementing Decision 2019/974 in all EU countries. Under the EU programmes, eight specific measures are eligible for funding, for technical assistance for beekeepers, combatting beehive invaders and diseases, rationalization of transhumance, analyses of apiculture products, restocking of hives, applied research, market monitoring, enhancement of product quality.

Proposed model

A value chain refers to the full range of activities required to bring a product or service from conception through the different phases of production, delivery to consumers and disposal after use (Kaplinsky and Morris, 2001). Value chain mapping can be complex due to some actors are involved at several activities (Roduner, 2004). A beekeeper can be a producer, consumer and a trader and is involved in few chains. Moreover, mapping of a value chain leads to identification of the principal functions at each stage, agents arraying out these functions and principal products developed.

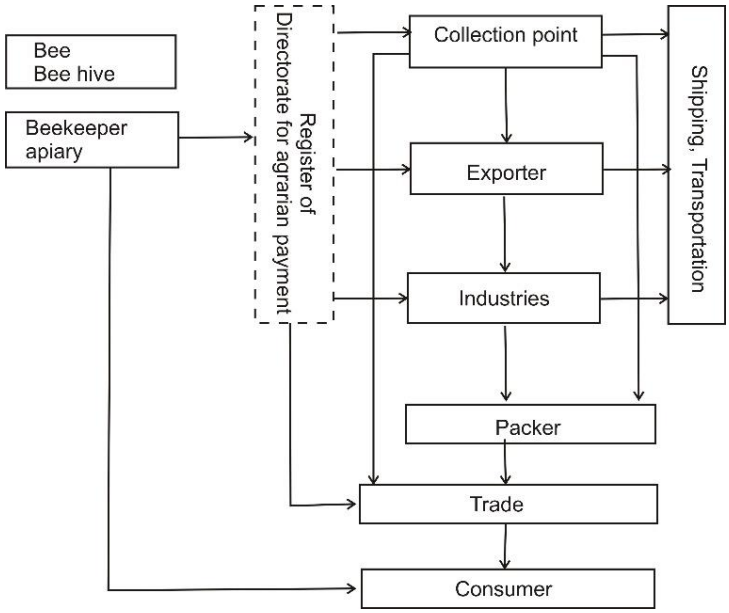

Figure 1. Traceability of honey processing and trade

In Serbia, it is obligatory for a beekeeper to register as an agricultural farm if he intends to participate in those chains. Before that, it is necessary to do an analysis of honey in certified laboratories. On the other hand, it is a very common case of direct cooperation between beekeepers and consumers with lack of laboratory analysis of honey. With some types of honey (acacia, lavander), deviations from the values of the evaluation indicators are allowed. In

addition, monofloral types of honey (acacia, lavender, linden, etc.) are more expensive, and this requires proof of plant origin by microscopic examination. Such an examination of honey was first carried out by Pfister in 1895, but in recent decades interest in this method has grown especially due to the great possibilities it provides for determining both the geographical and plant origin of honey, as well as its quality and purity. Microscopic analysis of honey is used for the following determination: quantity and composition of sediments (solid insoluble ingredients), geographical origin and botanical origin.

Nowadays, applications and microscopes are available at affordable prices for smart phones that are widely used, and the proposed model suggests their use for the purpose of traceability of honey. In addition, consumers are increasingly demanding, and are interested in the origin of honey. Smartphones can be used to provide information in the form of images about area, bee hive, pollen, origin, weather, etc. More details about microscopic pollen image analysis can be find in He et al. (2019).

Blockchain is a set of contemporary technologies that in synergy create a network that ensures trust among users. Blockchain is a decentralized and distributed database in which data cannot be changed or deleted and which enables the verification of transactions. The main parts of blockchain are block, chain and network. Cryptographic techniques enable encryption of all important data records in the blockchain, important for consistent data and record integrity.

A block is a list of transactions recorded in a book/register over a period of time. Transaction data is stored on various computers on the network, which are connected using the peer-to-peer protocol. The registry consists all transactions between participants chronologically. The network consists of "full nodes". The function of nodes is to continuously check the authenticity of records in the chain, and in the case of verification fail, to reject the proposed data blocks.

The approach of selecting an initially valid block of transactions is called proof-of-work which protects the network from abuse. In the end, the validated block gets its own unique timestamp and signature (hash), and as such is propagated to other nodes in the network. As adding validated block, the certificate counter for previously blocks increases and the probability that they are false decreases further. The reliability of the recorded data increases over time.

The process ensures that each block is formed in such a way that the previous and the next are irrefutably linked, and constricting blockchain. A chain is a hash that connects blocks. A hash is formed from the data previously present in the block. A hash can be thought of as a fingerprint of data locked into blocks based on order and time. Hash function creates an algorithm to map data of any size to a set of fixed-size bits.

Even if only one symbol is changed the algorithm will produce different hash value. SHA256 algorithm generates an almost-unique, fixed size 256-bit (32-byte) hash. The SHA (Secure Hash Algorithm) is one of many cryptographic hash functions. Examples of hashes are given below. It is noticed that if only one

letter is changed, the algorithm produces a different hash value. The SHA256 algorithm generates an almost unique 256-bit (32-byte) fixed-size hash.

Example of SHA256:

moj med

4df2af8645dbd1f83f16a6639487db9f5791259f64c9358afb5e0bc1f26fac2d

Moj med

e5f2b75f47230ad08ec3ee91930e8865883a6bb71f337fd8a81736961c8e05db

my honey

9db37284dcf0f16d4c12441d813dc27fbad07b8b14bf90039f1239b2f7ef784b

My honey

89a3db5c54730ffd2afdbab7e1527c998f58b03bafdbe6aeb5292d45361a7994

Blockchain process is illustrated on the next figure.

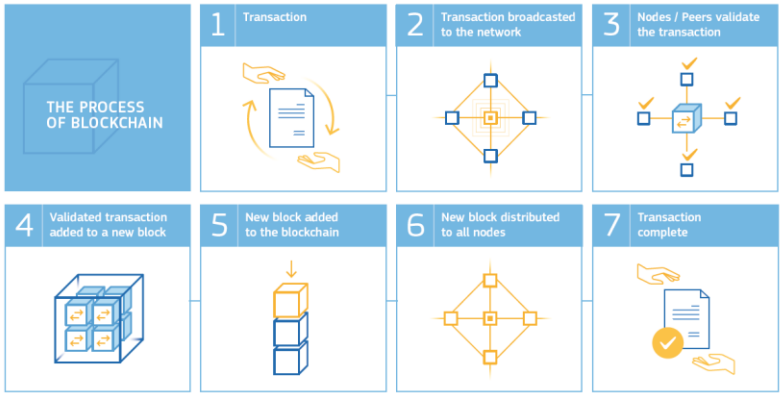

Figure 2: The Blockchain process

Source: European Union (2019).

The advantages provided by the application of blockchain technology in different domains is a combination of key features: decentralization, immutability, transparency and security. Proposed concept described below has the advantage of proving honey authentication at the beginning of the process rather than trying to identify adulterated honey at the end of the process.

The system starts with collecting data during production. Beekeeper uploads the detail document to the network. To register, the beekeeper sends a message to the system from a verified communication platform. According to the valid national regulations, honey is labelled in accordance with the Rulebook on the quality of honey and other bee products and the Rulebook on the declaration, labelling and advertising of food. The declaration states whether the honey is flower (nectar) or honeydew by origin, filtered according to the method of

production, etc. Additional information on the plant species, regional origin or some special quality characteristic can also be stated.

After registration, in the quick access, in addition to identification data, information on the number of hives and yard, and the type of beekeeper is recorded, as well as a certificate if the beekeeper has it. Additional information can be complementary attributes, for example the type of honey processing, rewards, or other information that the beekeeper finds useful. In the next stage, the beekeeper can upload pictures of the apiary, the environment, the floral source, etc. The blockchain records the transactions relating to this information, images, results of analysis and certification.

Figure 3. Proposed conceptual model

In the second phase, depending on the desired process (see figure 1), flow data is recorded in the blockchain (figure 3). For example, some processor in the system can place a purchase order directly to beekeeper and can oversee the smart contract. Approval procedure is actually the execution of smart contracts and sending the outcome results further in the network to check the veracity and reach a consensus (Bjelobaba et al., 2022). In case of agreement of both parties, the distributor (or beekeeper) ships the orders to the consumer. Information about transportation (shipping) uploading by distributor. Similar process is with intermediaries in the chain, where retailers sell honey to consumers.

System transactions are stored in the blockchain as the central system point, and all the participants involved in the system interact with the blockchain (Bjelobaba et al., 2022). All transactions and information are recorded, so that the end user can see them. Smart contracts permit communication between two sides. A smart contract embeds the terms of the contract in a combination of hardware and software, making them difficult to breach and prohibitively expensive. Therefore, smart contracts increase security by reducing attacks. In other words, a smart contract automates processes in blockchain technology. The application of blockchain technologies ensures data authenticity.

In this concept is possible to introduce cryptocurrency or sustainability tokens through blockchain technology. The introduction of cryptocurrency can help in maintain and developing the system, but it also brings specific problems in

implementation, such as regulatory policies. One more problem of implementation of the system is the low level of knowledge of blockchain technology and therefore lack of trust in this technology. Additionally, blockchain technology generally brings high operating costs and high-power consumption. New solutions bring possibility to implement green blockchain solutions consensus mechanism (Varavallo et al. 2022) based on minimal computational power.

Conclusion

The proposed concept brings the possibility of reducing fraud through smart tracking of the honey supply chain. Additional value is obtained through information about the beekeeper, apiary, area, relevant images as a universal tool of communication and other relevant information. In addition, today's consumers want additional information about the origin of honey, which can be achieved through the proposed system concept.

However, some limitation remains related to privacy and transparency of data, costs of implementations, limitations of the regulatory framework and willingness to use new technologies. The lack of funds for implementing the new technologies is the main problem, especially in low-income countries and developing countries where funding for agriculture is still relatively low.

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