

FOOD SAFETY IN THE SUPPLY CHAIN USING BLOCKCHAIN TECHNOLOGY

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ABSTRACT

The purpose of the article is to determine the importance of blockchain technology in food supply chain management. A practical reference to the adopted research aim was to indicate the usefulness of blockchain technology to build trust between food chain stakeholders. Research shows that the properties of blockchain technology can enable it to solve many problems and shortcomings of the current food production system. Its added value is primarily a significant increase in transparency of operations among all stakeholders using big data in all parts of the food chain.

Key words: food safety, blockchain technology, digitization in agriculture

JEL codes: D19, Q16, Q19

INTRODUCTION

Contemporary food supply chains include producers, suppliers, carriers, wholesalers, retailers, other intermediaries and even the customers themselves. They consist of many very diverse stakeholders, striving to achieve their autonomous goals. Managing them in a classical way often becomes an inefficient process, and even impossible, especially when considering the development of globalization. It is growing globalization that makes enterprises need new methods and solutions to improve the management of often dispersed resources. They can also be an important source of competitive advantage for food producers in Europe [Kowalczyk 2012]. The European agricultural model is undergoing transformation to reach a good competitive position in the global market. Its high placement in ranking can be demonstrated by the growing dynamics

of Polish food exports, which has reached the value of 107% [GUS 2019].

One of the areas to improve the competitiveness of food on the world market is its quality, achieved, among other things, by improving the supply chain. As Osmólski and Koliński indicate [2019], the supply chain is a series of independent, discrete, largely autonomous events controlled by marketing, production and distribution activities. Nowadays, the digitization of these processes is observed in enterprises as a result of the development of technology and the accompanying infrastructure. Digitalization of the economy is one of the most dynamic changes of our time, which opens new possibilities in creating business models. At the same time, it brings uncertainty and various types of threats related, among other things, to the social effects of manufacturing process automation or broadly understood food safety [Łobejko 2018].

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Figure 1 presents four levers of the digital transformation process: digital data, automation, connectivity, digital customer access. The response to the challenges associated with the rapid development of digital technologies is the digital transformation of various spheres of economic activity (Fig. 1). Digital transformation is a special kind of organizational change in an enterprise, sector, supply chain, and modern food safety systems. The availability of digital data, the automation of production processes, the interconnection of value chains and the creation of digital customer interfaces is transforming business models and reorganizing entire industries [Berger 2015].

Blockchain technology is particularly important in the supply chain control process. Blockchain technology is recognized as one of the breakthroughs of information technologies of our time [Treiblmaier 2018]. Its attributes and importance in building food safety systems are presented in the last part of the article.

MATERIAL AND METHODS

The purpose of this article was to determine the importance of blockchain technology in the chain management of food supply in the era of network economy development, known as Industry 4.0. Indication,

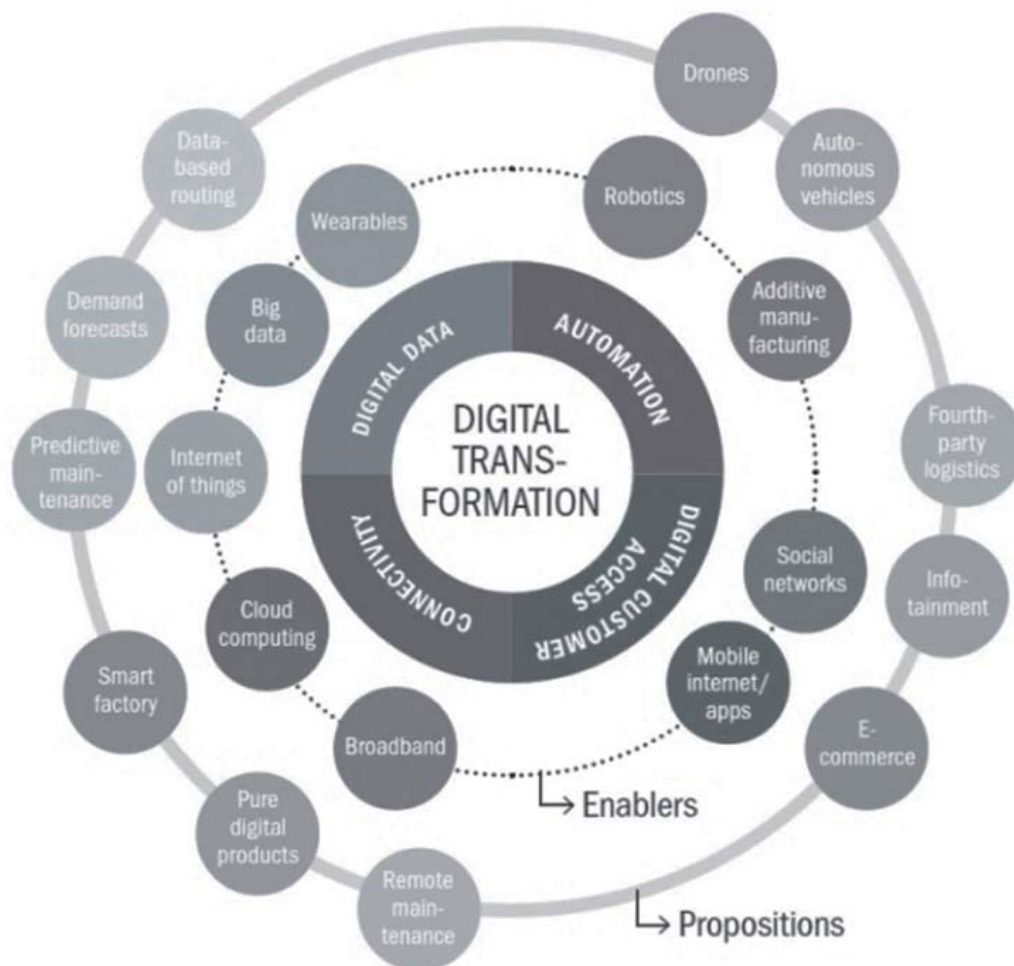


Fig. 1. Drivers of digitization

Source: Own elaboration based on Berger [2015].

which is based on the literature research of the impact of digital technology development on the security of the food chain.

Currently, food supply chains are changing very dynamically, but require permanent control [Osmólski and Koliński 2019] so that they do not become a source of danger for consumers. According to Szymczak and Sadowski [2019], there are still many crops and herds of animals exposed to diseases that can directly threaten the health or life of consumers. The sphere of food safety concerns not only threats of a biological nature, but also of an economic nature [Karasiewicz 2001]. A holistic approach to food safety issues has been included in the 2006 Act on Food Safety and Nutrition. In this sense, it means “all conditions, in particular: the substances and flavours used, levels of contaminants, pesticide residues, food irradiation conditions, organoleptic characteristics and actions that must be taken at all stages of food production or marketing – to ensure health and human life” [2006 Act on Food Safety and Nutrition]. The legislation also indicates the need to protect consumers against financial fraud that may occur when buying food. Therefore, actions are taken to improve the conditions of food availability and its health, using the potential of digital technologies [Kondo 2014].

It should be emphasized that the food supply chain is particularly exposed to all kinds of threats, which is a critical element of the functioning of society in each country [Kowalczyk 2017]. The most important problems in the food value chain include [Michalczyk 2019]:

- fraud in the trading of food, providing false information about the producer and the technological process of food production;
- illegal production and marketing of food without proper documentation;
- food-borne diseases;
- costs of withdrawing from market circulation any food that does not meet legally regulated requirements in a given country.

Figure 2 shows the food supply chain traceability system in force in Poland. Its basic feature is the current centralization. In this system, stakeholders rely on government supervision centres as a source of reliable information in food trading. This system is powered by data provided by individual stakeholders. At the same time, they have access to processed information and important messages, alerts that are announced in advance when a threat or potential crisis in the area of food safety is detected.

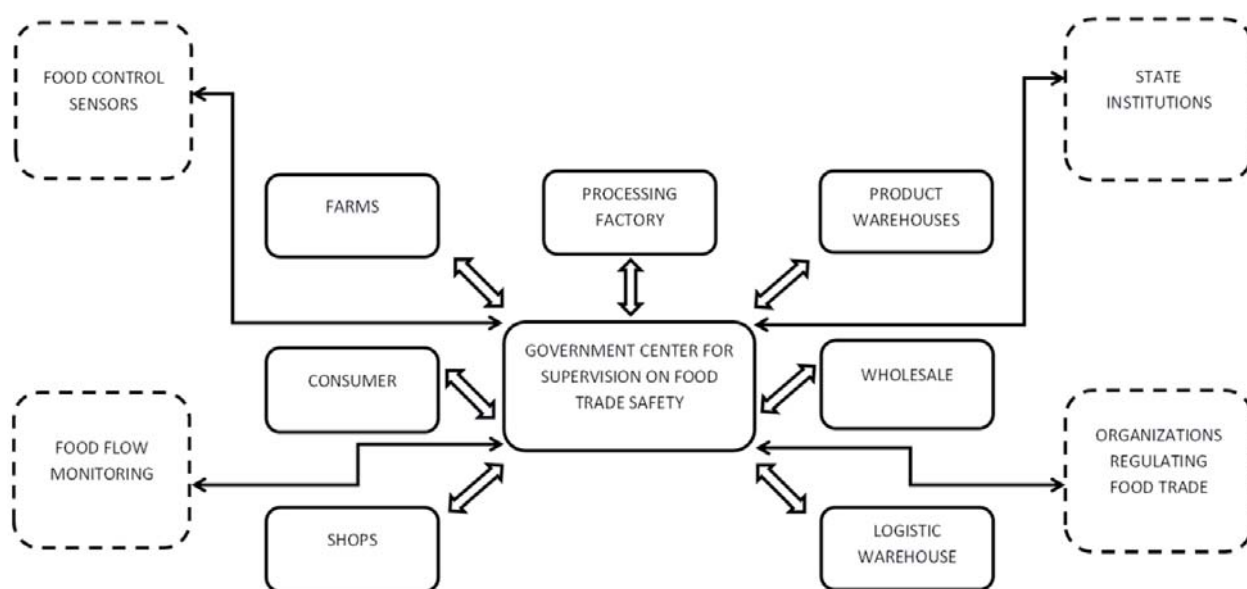


Fig. 2. Centralized traceability system for the food supply chain

Source: Own study.

It would seem that the centralized system correctly identifies the occurrence of any potential irregularities and threats in the food value chain, in all its links. However, the potential threat is always identified as soon as it occurs, which is a significant disadvantage of this system and exposes potential beneficiaries to negative effects. A given food product can go even through 5 to 10 stages of the food chain, from the farm (and even from the supplier of inputs, breeding animals and other components subject to further processing) to the end consumer [Juchniewicz 2015]. It should be noted that the majority of this turnover relates to cells falling within the scope of B2B units, i.e. appropriately structured and having appropriate resources that can be used to actively coordinate the food chain in accordance with safety regulations. According to Osmólski and Koliński [2019], the biggest downside to this centralized system of identifying the food supply chain is that it is monopolistic, not very transparent and finally, asymmetrical in the information flow. These serious imperfections of the existing system often lead to problems with the lack of trust of individual participants in the chain, or such prosaic irregularities as surprising as:

- falsifying certificates of origin of animals intended for further breeding or sent to a slaughterhouse;
- manipulation of information on the use of sensitive means of production, e.g. in animal production – antibiotics and other drugs, and in plant production – pesticides, in food processing – preservatives, etc.

For this reason, there is a need to implement new solutions using digital technologies to build a more decentralized system that will eliminate most of the negative attributes of the current one. This concept and the author's experience are presented in the next section of the article.

RESULTS AND DISCUSSION

The problem of food safety in the supply chain is a priority for every country. First of all, it results from the very large role that modern food chains play in the economy and society [Kowalczyk 2017]. This part of the article presents the opportunities and challenges associated with the use of blockchain technology in food supply chains in areas connected to ensuring the

safety and quality of food products. In assessing the potential of this technology, both the applications described in the literature and the effects of the selected pilot project, under which block-based solutions and applications were tested, were taken into account.

BLOCKCHAIN TECHNOLOGY

Over 10 years of experience in the use of blockchain technology is inseparably related to the history of the digital currency Bitcoin, created by the mysterious Satoshi Nakamoto. However, the idea of blockchain technology itself was already described in 1991 publication presenting a solution to the world, which was to digitally mark documents, preventing them from being altered or falsified [Haber and Stornetta 1991].

The system presented by scientists used a cryptographically secured block chain to store documents bearing so-called time stamps. In 1992, the so-called Merkle Trees, increased its efficiency and enabled the collection of many documents in one block. However, this technology was ultimately not used by anyone, and the patent itself expired in 2004, i.e. four years before Bitcoin was created. In 2004, world-renowned IT specialist and cryptographer Hal Finney (Harold Thomas Finney II) introduced a system called RPoW, Reusable Proof of Work. The system was based on receiving invariant and/or indestructible Hashcash, and instead created a token signed by the RSA key, which can then be transferred from person to person. Since the first Bitcoin users appeared, there has been an evolution in the perception of blockchain technology itself as a base technology that can be used for more than just creating cryptocurrencies. Also of importance was the appearance of the Bitcoin independent blockchain network called Ethereum, designed by Vitalik Buterin, which offered new functional possibilities – intelligent contracts [Buterin 2014].

Blockchain – a block chain – is a distributed database operating in a set of interrelated nodes (users) in which information (records) about various types of transactions and operations can be registered and stored [Crosby et al. 2015]. Blockchain technology creates, in fact, a digital book that records economic events, or rather individual operations throughout the

entire market chain. The information of the transaction is stored in chronological order and made available to individual stakeholders.

In blockchain technology, each block is connected to the previous one using a hash (link to the previous block), and a time stamp (time stamp), which defines the time of creation of the shortcut [Treiblmaier 2018]. Blockchain is a differently distributed, collective database, enabling their collection and communication by registering information through computers belonging to the same network. In contrast, the very innovation of blockchain technology relates to the combination of various fields: software engineering, distribution computer science, cryptographic science and economic game theory [Kisielnicki 2018].

Thus, blockchain technology basically creates a digital recording book. Each transaction information is stored in chronological order and made available to participating entities. Each transaction placed in the book is verified by system participants. A single transaction is a block, and a series of recorded transactions form an inseparable block chain. When you place information in a block chain, it becomes indelible [Steiner et al. 2017]. This is due to the fact that each block contains the end of the previous block, thus enabling them to be combined into a blockchain [Swan 2015].

The process of registering and validating transactions takes place without involving parties or third parties. Nodes validating blocks must find proof of work, i.e. solve the equation whose difficulty is regulated by the adopted algorithm. Thanks to these solutions, blockchain technology ensures security of data transmission as well as reliability and correctness of data. Each transaction and its associated value is visible to everyone who has access to the system.

BLOCKCHAIN TECHNOLOGY IN THE FOOD SUPPLY CHAIN

The presented analysis shows that the increased demand for transparency in the food supply chain causes an increase in the interest of modern digital solutions, such as blockchain technology. Figure 3 presents the concept of using blockchain in the process of building food safety. Due to the methodological limitations and practical experience of the author, the focus has been

on the proposed solution. First of all, attention is paid to preventive measures consisting in eliminating the symptoms of problem situations in the link in the chain in which they were detected. In this way, it limits the development of problem situations in the entire food market chain. The presented system is decentralized and is based on sharing data from all partners of the food value chain, collected in the digital book (ledger). In the case of animal production, this knowledge may relate to such parameters as:

- accepting the animal to blockchain records along with the opening balance;
- installation of responders on animals, enabling monitoring of their activity;
- body temperature anomaly or behavioural changes;
- treatment ordered;
- stages of the food cycle;
- readiness to receive by the meat processing plant after obtaining appropriate technological maturity;
- scope of preventive measures and substances used throughout the entire animal husbandry period;
- drawing up a description of the animal's silhouette and coding it in the form of a QR code.

The scope of these parameters was determined after consultation with partners from the Allflex company, which provides specialized “hardware” solutions (Fig. 3). Thanks to the decentralization of the food chain management process, all stakeholders (with access to the Internet) have the opportunity to observe changes in the food production process in real time. Blockchain technology allows a person to reflect in real time on the parameters that occur in food production. Of course, people can also proceed at further stages of the food chain, i.e. at the stage of transporting animals (including other food raw materials or products), at the stage of the food industry, at the stage of storage and distribution of food products. The final recipient will, of course, be the consumer, gaining knowledge about the parameters that have been registered in individual links of the chain. In this way, lasting relationships with consumers and the image of products distinguished by means of a brand are built. The author presented an opinion on this topic during a meeting in April 2019 at the Singapore Food Agency. The meeting concerned the possibility of exporting

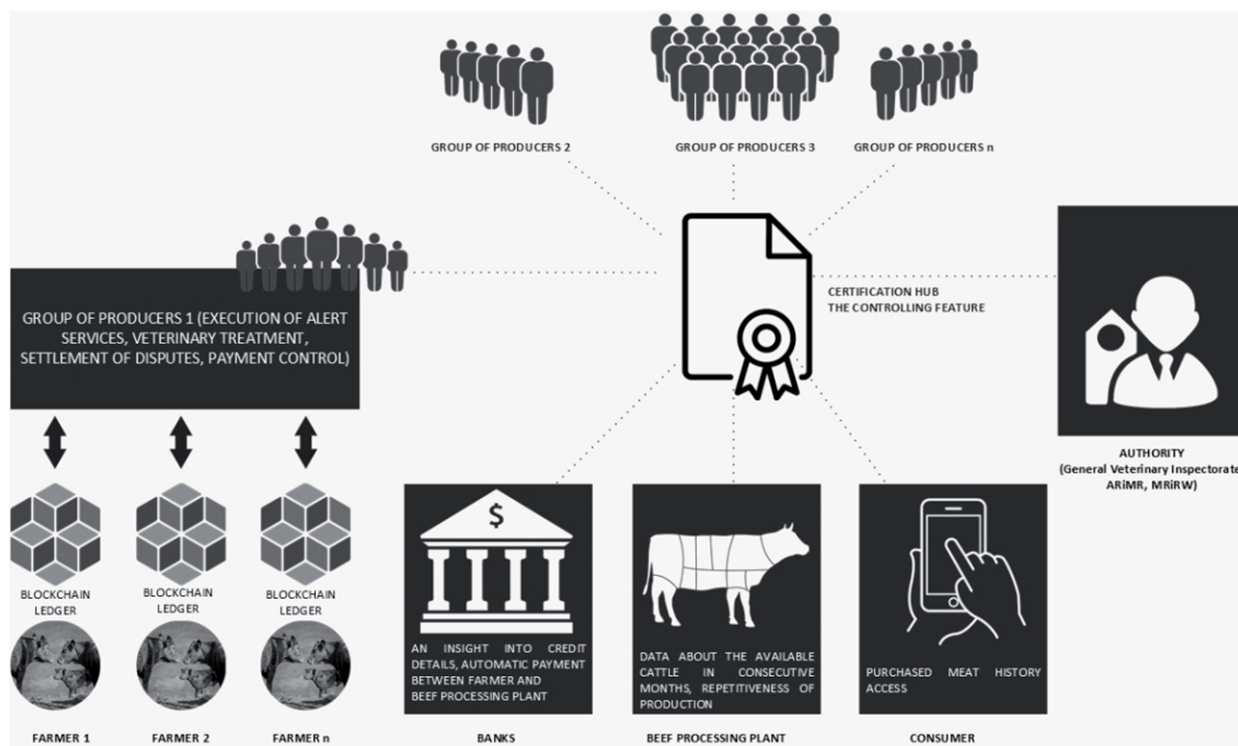


Fig. 3. The concept of building blockchain in the supply chain

Source: Own study.

Polish beef produced using blockchain technology to this demanding market.

It is also worth paying attention to the verification stage of parameters recorded during animal husbandry. The recipients of these parameters are, of course, farmers who cooperate within the groups of agricultural producers. It is very important to make the assumption that blockchain is implemented on farms associated in a producer group.

Farmers in the food chain are trading partners of consolidated customers, much larger and economically stronger, as well as better organized. In the relationship between producers, their suppliers and customers, farmers (next to consumers) are the weakest link. The low bargaining power of agricultural producers is mainly manifested by a small share in the final price of products [Milczarek-Andrzejewska 2014].

It seems that a good way to reduce the imbalance in market forces at the level of agricultural producer and subsequent links in the chain is to increase the eco-

nomical strength of farms through horizontal integration [Chlebicka 2017]. Horizontal integration can take the form of agricultural producer groups or producer organizations. Cooperation in groups enables, among others things, concentration of supply, joint production planning, concentration of demand for means of production, negotiating sales/purchase conditions, gaining new sales markets, activities for improving the quality of manufactured products, creating and promoting own product brands. Thanks to the existence of producer groups, links between producers, processors and trading agents, which are important for the smooth functioning of the market, are created, which contributes to supply planning and price stabilization (Fig. 3). Membership in agricultural producer groups can bring a number of benefits to agricultural producers – members. Those most frequently mentioned include improving the income situation of producers, increasing the quality of manufactured products and access to new markets. In this way, the use of block-

chain contributes to the level of economic security for all stakeholders in the food chain.

CONCLUSIONS, LIMITATIONS AND FURTHER RESEARCH

In addition to the many opportunities and possible scenarios associated with the use of blockchain, there are also problems and barriers that may limit a wider use of this technology in the food chain [Gajewski et al. 2017]. One barrier to the implementation of blockchain technology in food chain management processes may be insufficient resources and financial means necessary to undertake the required investments, e.g. on farms of agricultural producers. Some farmers may use their computer infrastructure with access to the Internet, which of course will reduce the level of investment required. However, operating costs include the purchase of sensors that will be installed on animals, which of course would also be another cost item.

An important problem from the point of view of shaping the effectiveness of the entire group of agricultural producers producing food is the problem of cooperation of all stakeholders [Jarka and Ruciński 2016]. Further research should concern the effects of implementing blockchain technology in agricultural enterprises differing in the scale of their operations.

The aim of the study was to present the possibilities of using innovative blockchain technology to improve the functioning of the food chain. Research shows that the properties of blockchain technology mean that it can solve many problems and shortcomings of the current food production system. Its added value is primarily a significant increase in transparency of operations among all stakeholders using big data in all parts of the food chain.

It is worth emphasizing that by using blockchain technology in the food chain, we can be sure that none of the characteristics of the product (certificate of origin, obtained certificates, etc.) can be reproduced. Most importantly, there are no information gaps, e.g. related to monitored features in animal production. This is possible thanks to responders that operate throughout the entire animal husbandry process. Its added value is primarily a significant increase in transparency of

operations among all stakeholders using big data in all parts of the food chain.

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BEZPIECZEŃSTWO ŻYWNOŚCI W ŁAŃCUCHU DOSTAW Z WYKORZYSTANIEM TECHNOLOGII *BLOCKCHAIN*

STRESZCZENIE

Celem tego artykułu jest określenie znaczenia technologii *blockchain* w zarządzaniu łańcuchem dostaw żywności. Praktycznym odniesieniem do przyjętego celu badawczego było wskazanie przydatności technologii *blockchain* do budowania zaufania między interesariuszami łańcucha żywnościowego. Jej wartością dodaną jest przede wszystkim znaczny wzrost przejrzystości operacji wśród wszystkich zainteresowanych stron korzystających z dużych zbiorów danych we wszystkich częściach łańcucha żywnościowego.

Słowa kluczowe: bezpieczeństwo żywności, technologia *blockchain*, digitalizacja w rolnictwie