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RESEARCH PAPER

An Overview of The Impact of Blockchain Technology on the Meat, Fruit and Vegetable Supply Chains

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ABSTRACT

The introduction of blockchain technology into the food supply chains represents a digital revolution that has led to widespread advances in tracking food security. This article presents a comprehensive review of the literature on the use of blockchain in the food supply chain. We have focused on the supply chains of meat, fruits and vegetables. The Literature review has been conducted from seven different databases. For more insight, we categorized meat, fruit, and vegetable articles into four groups: descriptive, prescriptive, conceptual, and predictive. Findings indicate that little valid and quality research has been done in this field and more research, and it is necessary to conduct more researches related to the application of blockchain in the supply chain of fresh products from the technical and managerial aspects.

KEYWORDS: *Blockchain; Food supply chain; Traceability; Food safety.*

1. Introduction

Food supply chains are interconnected and global. Food data and documents are reviewed only by a trusted third-party and stored in a private paper or database [1]. Food supply chain inefficiencies directly affect human quality of life in terms of lack of regulation and unfair competition. It has also increased the safety risks of food. This chain plays an important role in food prices and human health [2]. Information flow control in the modern food supply chain relies on central power. Centralization poses a threat to supply chain transparency and it creates problems such as issues of trust and information inequality. Companies can reveal information that is useful for their brand image, or they can also hide information. The vulnerability of the centralized supply chain to bribery is high, one failure point can disrupt the entire supply chain network [3]. In recent years, the food industry has experienced incidents related to food quality. Examples are melamine and horse meat, which have caused great damage to the national economy, threatened public health, and affected social stability [4]. In 2008, there was a scandal over melamine-contaminated milk in China. This scandal led to the death of six children and the illness of 300,000 infants [5]. An outbreak of Salmonella in 2009 also infected 700 people and killed nine. Examples of such cases in China include "Sanlo Toxic Milk Powder", "Trench Oil", "Clenbuterol", and "Sudan Red" that harmed people's health [6], [7].

The food sector has faced several crises throughout history, and with increasing market globalization, trust and control over information has become difficult [5]. Globalization of the food supply chain creates the need for high trust in the information exchanged, so more attention should be paid to food traceability. Advances in food traceability have been made by advances in information systems, but transparency and reliability of information are still fundamental. The complexity of the food supply chain makes it increasingly difficult to track contamination, as each food product goes through several stages within this chain [8]. Also, the traditional food monitoring system, with problems such as the lack of industry chain and island data, has caused the existing system to have irregularities and delays in responding [4].

The globalization of trade and food production has increased access to food and consumer

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options. Also, the time of transportation and distance of food from farmer to final consumer has increased. These cases prolong and complex the supply chain and increases food safety and tracing challenges. Food safety issues have caused many concerns in recent years. In order to prevent food safety problems, it is necessary to establish a reliable traceability system [9], [10], [11].

Blockchain is a solution for tracking and ensuring transparency [12]. This technology also has a high potential to increase members' trust in the food supply chain [8]. The data is stored in blockchain chronologically and manipulation becomes impossible. In addition, this technology allows all parties involved to review the current location as well as the entire product history. Also, due to the data immutability technique, this technology creates an unparalleled level of credibility [13].

This article is a review of the literature on the use of blockchain in the food supply chain. Especially, we have focused on supply chains of meat, fruits and vegetables. This article provides valuable information for managers and activists in this field about the research agenda. This study focuses mainly on blockchain components that improve tracking in the food supply chain. Blockchain can be an effective and safe solution for groups of people with certain religious beliefs, such as Muslims who seek to prepare meat with Islamic slaughter. We seek to provide a complete picture of the research process that has been conducted in this area. We also intend to specify the number and types of research that has been conducted over the years on the various components of blockchain in the food industry. This article also discusses what needs to be done in the future. Our systematic review has been done with the aim of answering the following questions:

What effects does blockchain have on the meat, fruit and vegetable supply chain?

Which components of blockchain have been surveyed in the food industry?

The body of this paper is organized as follows. Section 2 describes the fruits and vegetables, meat supply chains. Section 3 describes blockchain technology and its effect on the food supply chains. Section 4 presents research methodology. Section 5 includes discussions and findings, and the last section presents general conclusions and suggestions.

2. An Overview of The Meat, Fruit and Vegetable Food Supply Chain

2.1. Fruits and vegetables supply chain

Fruits and vegetables are essential in human nutrition and a rich source of protein, carbohydrates, vitamins and minerals. These substances are also referred to as protective foods and are of great importance. Demand for such foods is increasing as the population grows. Due to their very short and perishable shelf life in nature, these items need proper transportation, handling and storage to reach the customer in a fresh state. Fruits and vegetables (F&V) play an important role in a nutritious diet [14], [15]. The potential and important contribution that fruits and vegetables have in reducing the risk of cardiovascular disease and cancer determines their core value. The average recommended daily intake of fruits and vegetables, according to the WHO / FAO, is 400 g per person per day or approximately 150 kg per person per year [6].

Insufficient cold chain capacity, lack of cold chain facilities and lack of cold chain network are some of the issues related to cold chain. F&V supply chain full of losses and waste after harvest due to scattered and long chain, intermediary dependence, inefficient system, poor quality of distribution and insufficient cold chain infrastructure facilities, etc., which leads to the realization of unfavorable producer prices and exorbitant prices paid by consumers. F&V sector creates a great opportunity for agricultural trade and the development of rural areas through a well-established supply chain, and this sector is growing. The basis of an efficient supply chain is having the right information. Lack of adequate and proper information about market demand makes successful supply chain implementation difficult. Poor information causes high losses, late delivery of goods in the market, non-realization of prices, and etc. [6], [15].

The role of transportation in the supply chain is very important and without proper transportation, it is not possible to deliver goods with proper quality and at the right time to the customer. Due to food perishability, required controlled temperature, and short shelf life, transportation of perishable foods such as fruits and vegetables plays a more important role. Fresh F&V are sensitive to temperature and perishable. The difficulty in maintaining the aesthetic, nutritional and health characteristics of fresh food is a direct problem during transportation. Physical, biological, and chemical changes that occur throughout the supply chain cause the deterioration of fresh food. Also, over time, the

sensory, nutritional and microbiological quality is compromised and the shelf life of the products is reduced. To improve the quality and safety of food, as well as reduce operating costs, production facilities must ensure that the cold chain is intact. Time and temperature are two factors that play a role in reducing the sensory, hygienic and nutritional quality of perishable materials [16], [15]. A very important factor in the food sector /industry is quality because it is directly related to people's health. The effect of quality in supply chains is strong and helps to reduce customer rejection and efficiency.

Farmers are the main source of fresh agricultural products and without their proper knowledge and awareness, the supply chain cannot be efficient. Other issues include islanding (large numbers of local intermediaries and traders reducing the farmer's share) and integration issues can be mentioned [15]. Also, supply chain management (SCM) of fruits and vegetables are more complex than other SCMs due to the perishable nature of the product, high fluctuations in demand and prices, increasing consumer concerns about food quality and safety, and dependence on climatic conditions [6]. In addition to F&V importance in increasing farmers' incomes and creating new job opportunities, F&V crops are high value crops. Therefore, the cultivation of these products has a vital role in the prosperity of a nation and is directly related to the happiness and health of the people. The F&V sector is perhaps the most profitable investment of all agricultural activities, as it provides ample employment opportunities and opportunities to increase the income of the farming community. F&V is a major part of the global economy and a raw material for many industries. Among agricultural products, F&V have received the least attention [17]. In developing countries, small farmers often have restrictions on access to technology and services and market integration [18].

2.2. Meat supply chain

Meat supply chain provides the most important source of protein for humans, starting with raising livestock and going through the slaughter and processing of fresh meat. Important actors involved in a meat supply chain include suppliers of products and feed, primary farmers or producers, transportation, slaughterhouses, conversion industries or processors, wholesalers, distributors and end consumers [19]. Figure (1) shows the meat supply chain.

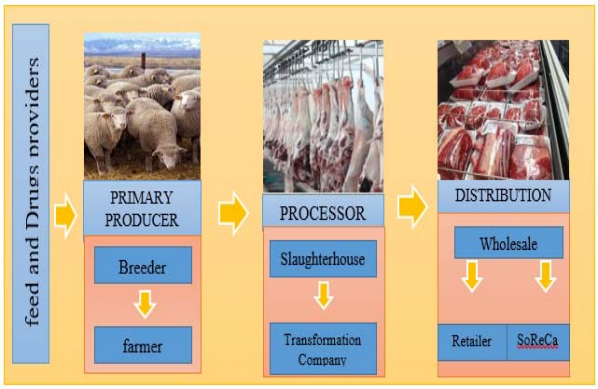

Fig. 1. Meat supply chain

The meat industry in particular, and the food industry in general, have changeed in their structure, such as market demands for technology modernization, globalization, consumer diversification, and shorter lifetime of product. Industry stakeholders were persuaded to work together. So, they formed a coalition that could potentially increase economies of scale, expand market access, reduce risks, accelerate market access, and open up new places to use advanced technologies and special skills [20].

Traceability plays an important role in the food industry due to its direct relationship with food safety and quality. Ensuring the safety of food products is possible only by following them. Due to food scandals that have occurred in the meat sector in recent years, the lack of common standards for encryption and information management and the inability to link food products with elements involved in the conversion process are highlighted. An effective tracking system can provide a complete link between the information provided to consumers and the operations performed on meat and animals. The rules only require the protection of minimum data, and no international standards have been established to define the format of this data and the data standards to be used. Each

national system is, in fact, different in terms of the data stored, the data format, and the standards adopted. In addition, no existing national system has multilingual capabilities and data is stored only in the national language [19].

Digitalized supply chain tracking systems can offer broad perspectives on both safety improvement and perceived quality. However, in most cases, the link between physical goods and information is difficult for agri-food items. In the case of meat products, high consumer confidence and good food reputation affect the customer shopping experience and thus lead to higher sales. Through the flow of privately verified information subject to a low degree of standardization of the identification system and dependent on third-party authentication, high-quality meat producers are increasing their revenue, which is now costly to maintain. This situation has led to costly and discontinuous information flow about meat supply chain traceability, excluding a priori a large number of potential stakeholders [10].

3. Blockchain Technology and Application of Blockchain in Food Supply Chain

3.1. Blockchain technology

The concept of a decentralized peer-to-peer ledger was introduced in 2008 by Nakamoto. This technology is used to record transactions, track assets and build trust as a common, unchanging office [3]. Blockchain is a distributed database of records and holds all kinds of information such as records, transactions and events. This technology is a set of data that consists of a chain of data packets (blocks) and a block consists of several transactions. With each additional block, the blockchain expands and displays a complete general ledger of transaction history. The blocks are authenticated by the network using cryptographic tools. Transactions and each block contain a time stamp, a nonce that contains a random number to confirm the hash, and the hash value of the previous block (i.e., parent). The hash values of each block are unique, and this effectively prevents fraud because the hash value changes as a block in the chain varies. By a consensus mechanism, the validity of transactions in a block and the validity of the block itself is agreed upon by most network nodes, and so the block can be added to the chain. Transactions of this technology are updated with peer-to-peer repetition. Blockchain eliminates the role of third parties or intermediaries and also prevents malicious activity by allowing all participants to view all operations. This technology is accepted as a solution to fundamental issues such as trust and the prevention of tampering with information transparency. Blockchain strengthens the traceability of production and logistics activities and also maintains the integrity of transactions. Confirmation and storage of transactions is done continuously by digital blocks. The decentralized blockchain feature allows the same information to be distributed throughout the network, and no single node can control transactions. In this structure, any action to change and correct the information without the approval of all stakeholders is prevented and has a permanent seal. This creates a collective responsibility to ensure the safety and reliability of the data.

Key elements of blockchain architecture include: node, hash functions, proof of work, mining, time stamp server [14], [21], [22], [23], [24]. Figure 2 shows a very simple example of a blockchain structure.

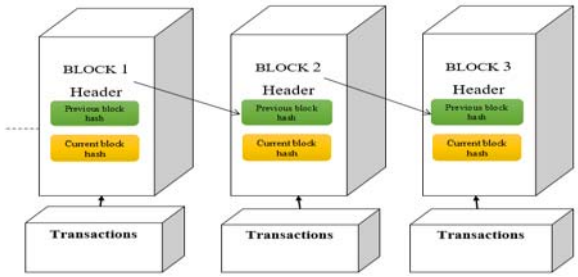

Fig. 2. Simple structure of blockchain

3.2. Application of blockchain in food supply chain

Fresh food and food processing at all levels of the food supply chain are at risk for health and safety, so assessing the quality of products from farm to fork is challenging. Transferring the food industry to a global value network to prevent food scandals requires faster response times and tracking systems. This technology affects key supply chain goals such as flexibility, speed,

quality, cost and risk reduction and increases accountability and transparency [11].

Issues related to food waste have attracted a lot of attention in recent years. In a sense, demand for fresh and high-quality products has increased, with at least one-third of food production to be destroyed during the supply chain. One of the most important tools for reducing food waste is information exchange. Sharing information leads to improve decisions about the amount of supplier orders and vendor inventory allocation among retailers. The use of this technology improves the exchange of information between all parts of the system [25]. Also, one of the most important issues we face today is the issue of food safety. Food safety issues seriously threaten consumer confidence in the food market and consumer health. There is no easy traceability anywhere in the supply chain in the traditional agro-food production system. As a result, it is very difficult to examine food production data for the source of disease outbreaks at the time of food outbreaks. This challenge can be addressed by a blockchain-based food production system [26].

One of the most important challenges in the supply chain is traceability. Tracing any product manually requires both a lot of attention and difficult task. To track goods, the existing system uses a centralized database system. The nature of an immutable, decentralized general ledger called blockchain, which is managed by a set of computers, is suitable for tracking in a supply chain. The blocks are added to each other in chronological order to create a non-manipulative chain. This immutability brings trust among the participants. They can also build trust between different participants through the consensus protocol. Traceability is very important for the food supply chain. Due to the communication framework that exists in the food ecosystem, traceability has become a time-consuming task.

The blockchain structure ensures that each player creates and shares data points securely along the food value chain to create a traceable and responsive system. High-data points are quickly recorded with tags identifying their ownership without any changes. Therefore, travel record of a food from farm to table is available for real-time monitoring [27], [28], [29].

Blockchain is a valuable technology for assisting the government in tracking, monitoring and auditing the food supply chain, and for helping producers record transactions. This technology can not only benefit producers, customers and regulators, but also improve the efficiency, processing and circulation of the food supply chain [30]. At the following, we will especially focus on the application of blockchain in meat and fruits and vegetables products.

3.2.1. Application of blockchain in the meat supply chain

Meat is a staple food. Despite its high demand, many companies ignore meat safety and distribute rotten and old meat among consumers. There are scandals over substitute, stale and contaminated meat around the world. Among the most famous are horse meat scandals in Britain, expired meat scandals in China, contaminated meat in Brazil, and donkey meat in Pakistan [31]. The 2013 UK horse meat scandal identified the industry as a high-risk sector. The scandal marked a major breakdown in food supply chain traceability and the possibility of harmful components. For example, sport horses could enter the chain, along with the banned veterinary drug phenylbutazone. Regulators and operators are looking for technologies such as blockchain to improve visibility in operations due to the risks associated with certain food groups [32], [17]. 90 percent of the total production of fresh meat have poor logistics. Poor logistics increases costs and waste [4].

The importance of meat safety and quality regulations for consumers has been highlighted over the past decade by the meat scandal in Europe. The need for transparency and tracking in the food supply chain during these crises also became apparent. In 2000, the European Commission introduced regulations for the labeling beef for all EU member states. The law made it mandatory to label the correct information for the meat from the start of the beef quartering process (cutting the meat into four parts) at the slaughterhouse until the final packing at the point of sale. This is the most advanced tracking system in the European Union. It still has major shortcomings due to the difficulty of regulating it and not considering imports from other continents. There are also several weak links in the information-sharing chain, such as the lack of a mechanism to ensure the validity of shared information, especially between slaughterhouses and agriculture, information manipulation and human errors.

Companies today recognize that consumers have more information about the products they buy, so transparency is inevitable [33]. The Cattle Tracking Systems Project was launched in early 1998 in the UK. In this project, they used the electronic tag RFlD (radio frequency

identification) to track and identify animals such as horses, cows, pigs and sheep in the raising stage. The European Union passed a law in 2008 to pressure livestock farms to use electronic sheep identification. In Japan and the United States, from planting to distributors and retailers throughout the supply chain, the RFID system has been used to track food. For the producer, wholesaler, retailer and consumer, it provides management information and food safety data. RFID is widely used in the logistics industry. This increases the quality and safety of agro-food products [34]. RFID requires physical sensors attached to the product itself. The product path can be tracked by its sensor. For livestock in the meat industry, these applications may provide better tracking, although these sensors are easily removed. Also, the correct use of RFID labels is not regulated by any independent control mechanism or institution. Methods based on DNA barcoding are more advanced. At the time of slaughtering the animals, in order to be able to trace the product to its original, DNA-ID is placed on the product packaging. This method is technically feasible, but it lacks reliability due to the lack of any control or verification system. DNA codes and ID tags can be manipulated and changed without anyone noticing [33].

Blockchain can revolutionize the halal industry and improve the success of the Halal meat supply chain through collaboration between value chain partners (logistics service providers and certification bodies, farmers, distributors, retailers, and meat processors). It also helps to increase the authenticity of Halal products and food safety by ensuring that more Halal guidelines are followed in agriculture, slaughter, processing and distribution [35]. Traceability created by blockchain is a solution to increase food safety. This technology can be used to access the information of each supply chain node. This technology can be used to access the information of each supply chain node. Because of its characteristics, the data are more reliable and tamper-proof [36]. A decentralized, unchanging, and secure certification system for food and agricultural products from local farms to the global table is provided by this technology [31]. Ensuring information on the origin and processing of meat by blockchain increases the reliability of supply chain tracking and its robustness against possible external inferences. Blockchain has the potential to solve some of the problems associated with ensuring an efficient and reliable tracking system by a trusted third party [10].

Providing healthy and quality food, especially those that have special storage conditions such as meat products, is one of the concerns of companies.

3.2.2. Application of blockchain in F&V supply chain

In recent years, the food industry has experienced incidents related to food quality. In March 2018, an outbreak of Escherichia coli (E. coli) was found in lettuce. During the month of the outbreak, 29 states were affected, with one death and 149 illnesses. The outbreak of Escherichia coli in Germany was due to the contamination of fenugreek buds in 2011 [5], [3]. 80% of the total production of vegetables and fruits have poor logistics. Poor logistics increases waste and costs [4]. One of the problems with the fruit and vegetable supply chain is that their prices vary greatly from farm to fork. Also, in a short time, their quality deteriorates. In addition to the damage caused by decay and its deterioration, there are losses during the transportation and marketing of fruits and vegetables. In order to identify and prevent these losses, by sharing and recording all data from the harvest of vegetables and fruits to their storage, distribution and sale to the customer, traceability is ensured.

Blockchain technology with visibility and tracking can be the solution to many supply chain problems. With the help of this technology, all transfers and transactions within the supply chain can be recorded in a way that can be seen by all stakeholders. Looking at today's supply chains, RFID technology, barcodes and sensors are frequently used. RFlD tags cost a lot, and these tags can be simulated, which leads to the spread of counterfeit items in the food supply chain. There is also debate about whether the information it provides is reliable. There is still the possibility of cyber-attacks as a threat to them [36], [15], [34], [37].

The exchange of goods is not very transparent and is also based on heavy and paper settlement processes. Also, there are many risks between sellers and buyers when exchanging value. Due to the vulnerability of transactions to fraud, intermediaries are involved, which leads to an increase in overall transfer costs [38]. The use of blockchain in the supply chain with the help of smart contracts creates superiority. This provides a more cost-effective, faster and safer transaction through the certification process. Traditional buying transactions require an intermediary or organization to ensure that the parties comply with the terms. But, blockchain automatically

complies with smart contracts by avoiding the need for this third party. When starting the production of vegetables and fruits, the place of production, soil quality, seeds and the type of fertilizer used are determined. Also, the amount of water and environmental conditions are entered into the system during development, planting and harvesting time. This information can be seen by all parties involved in the chain. The information of the farmer who performs all these operations is also entered into the system and facilitates communication with the farmer if necessary. Also, in response to the risk of spoilage of these foods during transportation, environmental conditions and time of transportation are included in the system in a way that can be seen by the customer, the place of sale and the manufacturer. By this way, spoiled foods can be idec ntified faster and removed from the chain before reaching the consumer. By guaranteeing the receipt of healthy fruits and vegetables just by seeing the product, the customer can replace online shopping by face-to-face shopping. In a way that the farmer can follow, the prices of various vegetables and fruits are determined according to the real demands [36].

A pilot study of a blockchain-based tracking system was conducted in 2016 by Walmart and IBM. This collaboration was done to investigate the Mango tracking system from the store to the farm. According to the current tracking system, it took about seven days to gather information about Mango movements, forcing each stakeholder to contact each other to identify the details needed. Blockchain eliminates call and waiting time for other stakeholders to respond. With the help of blockchain, tracking a mango package takes only two seconds at Walmart. Mango movements are recorded along the supply chain by each stakeholder and can be reviewed at any time [3], [26], [39]. The food supply chain becomes more sustainable by blockchain by targeted recall of food and increasing efficiency. In this technology, product information is updated at a speed close to the moment. As a result, stakeholders can both react more quickly to the situation and learn more about the product flow [3].

4. Methodology

In this paper, seven different databases with heterogeneous strings are used to collect articles. These few databases have more extensive resources and have been used much more extensively in blockchain research in the food supply chain. The name of the database and the number of articles related to each database are given in Figure (3). This research uses a review strategy called "A Best-Evidence Synthesis", a method that incorporates the best features of meta-analytic and traditional narrative review. Best-evidence syntheses, using justified and coherent standards, identifies meaningful and unbiased information from empirical studies and discusses each study in some detail and integrates the effect size between studies into justifiable category [40]. To narrow the scope of articles, the keywords "food supply chain", "blockchain", "food industry", "fruits and vegetables", "meat", "name of each vegetable and fruit", "chicken, pork, beef", Sheep, horses "and the operators +, and" are used. In the initial search, 252 articles were collected, and after reviewing the titles of the articles and reading the abstract and removing duplicate articles, 96 articles were selected for evaluation. About 31 of these articles were Survey-case study papers, 5 review papers, 14 conference papers, 2 report papers, and 44 descriptive papers, shown in Figure (4). Several conference papers that had a case study were grouped in the survey-case study group. Although all 96 selected articles are related to the use of blockchain in the food and agricultural supply chain, about 13 of them are related to the fruit and vegetable supply chain and the meat supply chain. 2 of these articles examines both supply chains. Our literature review does not include dissertations and books.

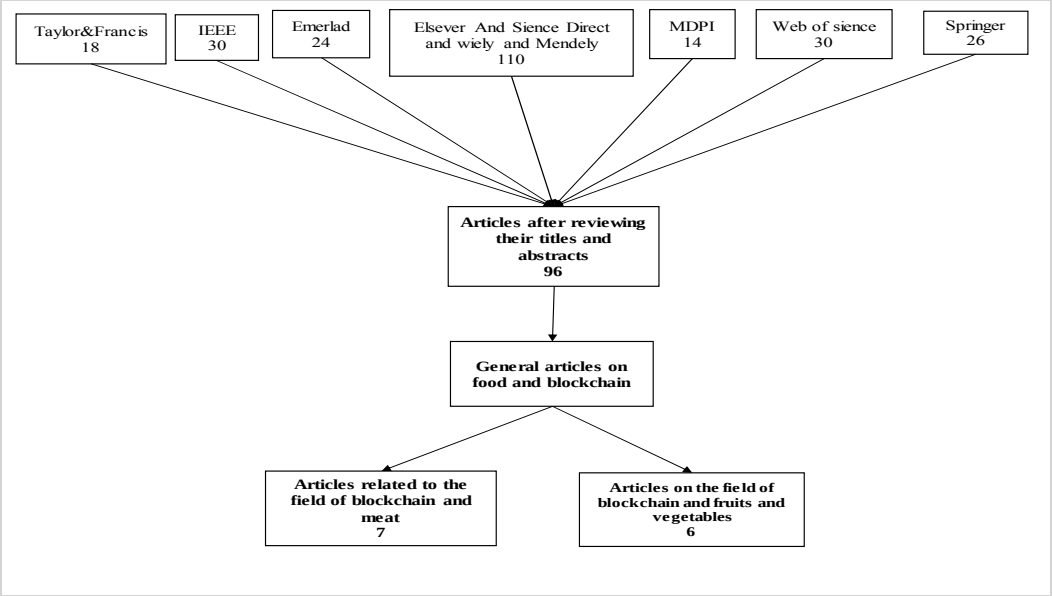

Fig. 3. The used scientific databases

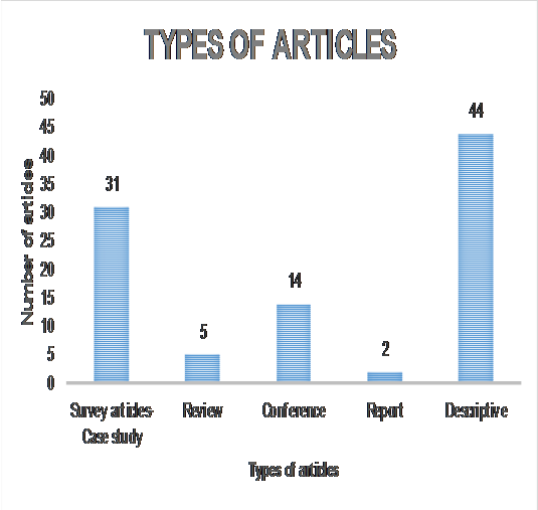

Fig. 4. Types of articles collected

We also categorized articles related to meat, fruits and vegetables into four groups: predictive, prescriptive, descriptive, conceptual. This category is based on the grouping used by [41] in their article.

Predictive (8%): predictive articles answer the question, where will blockchain penetrate the supply chain? It is done considering the possible applications of blockchain. Possible applications such as product tracking, financial settlement, process automation and management, cross-border digital integration of several stakeholders are examples of these applications.

Descriptive (23%): descriptive articles answer questions about how to deploy blockchain in the supply chain? In product and source tracking, experimental designs show the usefulness of blockchain application.

Prescription (31%): prescription articles offer technical and commercial solutions to current supply chain problems. In these articles, specific problems of the supply chain are identified and blockchain is suggested as a solution. These articles answer the question of how blockchain should be deployed in the supply chain.

Conceptual (38%): conceptual papers answer the question of what blockchain means for the supply chain. To better understand this technology, these articles interpret the values of blockchain and present its features and implications for the supply chain. It also discusses the new pattern of food supply chain management by blockchain [41]. The calculation

of the percentage of articles (predictive, conceptual, descriptive, prescriptive) related to the supply chain of meat, fruits and vegetables has been obtained from a total of 13 articles found in this field.

1 of these articles are from the predictive group, 5 from the conceptual group, 4 from the prescriptive group and 3 from the descriptive group. A number of components have been explored in these articles. These components include: traceability, transparency, benefits and impact of blockchain on production system, performance, process management, optimization and impact on the food supply chain, problems of the manufacturer's office and increasing trust. Seven of the articles examined the traceability component, two of which, along with the traceability component, also examined the transparency index. Other articles have examined the benefits of blockchain and its effect on the food supply chain. Only 5 of these studies have been case study in their research.

This grouping is presented in Table (1). Table (2) (see Appendix A.) contains the various research trends that have examined the types of blockchain components over the years in the food supply chain. This table focuses on the main components of the research, the number and process of research on these components over different years.

Tab. 1. Grouping articles of meat, fruit and vegetable supply chain

Research types	Paper	The component under consideration	Applied areas	Features and Findings
Predictive Papers	Yildizbasi And Ustunyer (2019)	Integration of blockchain technology in the supply chain management process (food distribution and marketing)	Fruits and vegetables	The purpose of this study is to record and simplify audit systems by integrating with blockchain in the process of supply chain management of fruits and vegetables without the need for intermediaries.
Conceptual Papers	Sander et al. (2018)	Traceability And Transparency	Meat supply chain	Implementing blockchain as a system of transparency and traceability through understanding the quality has a great positive impact on consumer purchasing decisions.
	Kamath. (2018)	Traceability and challenges of implementing blockchain	Meat supply chain and Fruits and vegetables	This case study highlights the opportunities to use blockchain solutions to increase safety and reduce waste and the challenges of implementing blockchain technology.
	Waqas Khan et al. (2020)	Supply chain optimization (supply chain effectiveness)	Meat supply chain	This paper proposes a supply chain optimization system using advanced technologies in the food industry. The proposed method handles a large number of users without affecting system performance.
	Osei et al. (2018)	Opportunities and benefits of blockchain in new products	Fruits and vegetables (Fresh Produce)	The complexity and novelty of the UK supply chain is the main obstacle to blockchain acceptance in this area.
	Stranieri et al. (2020)	The effect of blockchain technology on food supply chain performance	Meat supply chain and Fruits and vegetables	Findings indicate that the implementation of blockchain creates economic benefits in terms of profit or ROI (return on investment). Better information management is also established throughout the agri-food supply chain.
Descriptive Papers	Cao et al. (2021)	Strengthen trust in traceability	Meat supply chain	This study uses a scientific design method to test and design across the beef supply chain for a blockchain-based tracking system between China and Australia. Blockchain's authentic traceability prototype will generally increase trust and confidence in Australian beef products among Chinese consumers.
	George et al. (2019)	Traceability	Meat supply chain	This article examines the main methods of food traceability and proposes a restaurant prototype. In addition to strengthening the traceability of food, the prototype also helps in grading the quality of food for human consumption.
	Meidayanti et al. (2019)	Traceability	Meat supply chain	In this paper, the design of a traceability system as a business process flow with BPMN (Business Process Model and Notation) in the meat supply chain is described.
	Ferdousi et al. (2020)	Traceability	Meat supply chain	A contract-based intelligent framework is proposed using an authorized blockchain network to solve tracking problems to prevent harm to the business

Prescriptive Papers				of farm owners. The technical contribution of the article is to protect data ownership and user privacy.
	Chan et al. (2019)	Traceability And Transparency	Fruits and vegetables	In this study, using blockchain, a framework for a traceable and transparent supply chain management system in the Malaysian food-agriculture sector is presented.
	Rejeb (2018)	Traceability	Meat supply chain	In this study, for real-time tracking in the halal meat supply chain tracking system based on the implementation of the Islamic dietary law in HACCP (Hazard Analysis and Critical Control Points), IoT and blockchain is proposed.

5. Discussion and Findings

According to Table (2) and Figure (3), it is quite clear that research on the application of blockchain in the food industry is at the beginning of the road and in the growth stage. Most articles have investigated the impact of blockchain on the traceability component in supply chains. Since then, the benefits and challenges of blockchain in the food supply chain and its impact on supply chain management, food safety and security have received more attention from researchers. Research on the impact of blockchain on price, cost, security, reliability, accessibility and symmetry of information, privacy, fraud prevention, visibility and quality, and product origin is very limited. Although research in this area has been increasing over the years, we see little empirical evidence in this area. It is quite obvious that blockchain has been implemented in a few countries and there is little knowledge and insight about the effects of blockchain in this area. The effects of this technology in reality should be further investigated so that more tangible results can be collected based on real data and made available to stakeholders and activists in this field. We also show the process of examining different components in the supply chain with a clustered bar diagram in Figure (5).

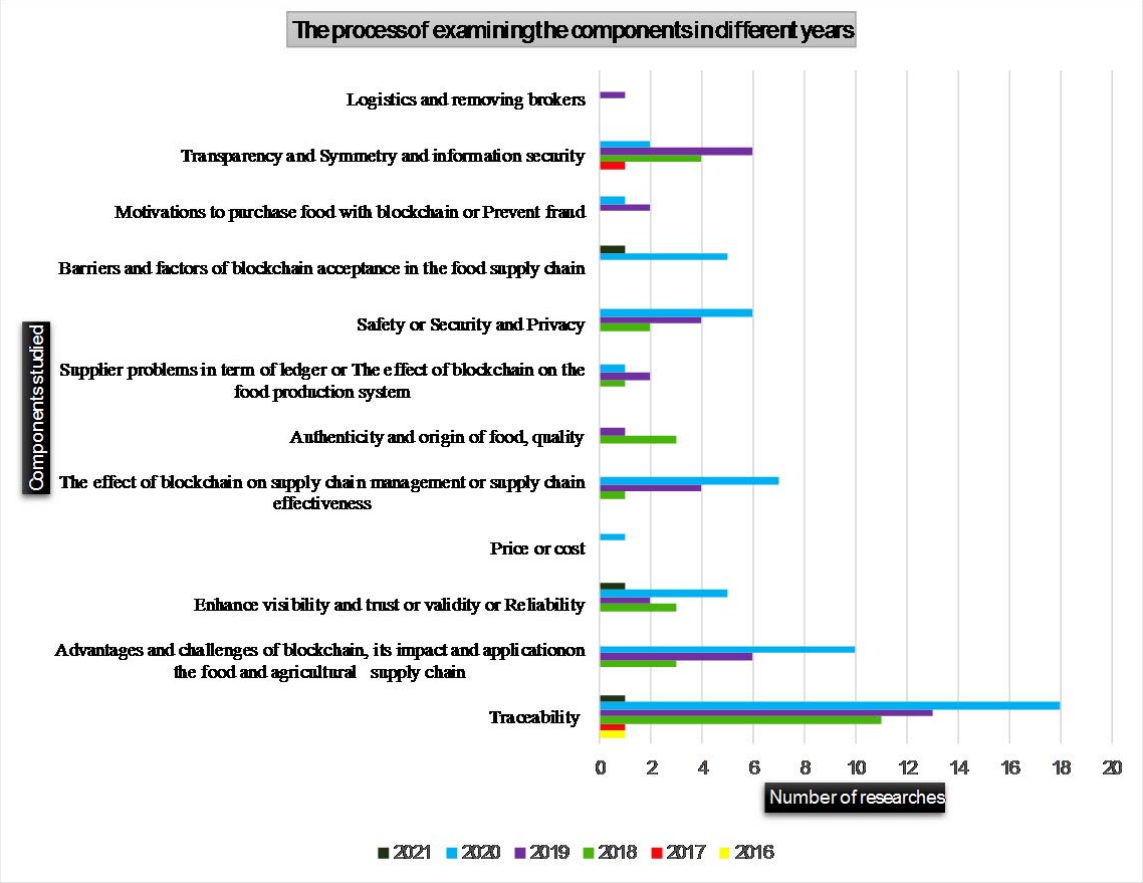

Fig. 5. Investigating the components of blockchain in food industry

As the population grows, consumers' eating habits and lifestyles change nad human society's need for protein is increased. On the other hand, with the advancement of science and the rise of culture in societies, human beings have become more aware of the basic nutrition and quality of consumables. Foods prepared from livestock play an important role in the growth and repair of tissues and health due to the existence of essential amino acids. The supply of animal protein in different societies is done from different sources according to people's tastes, geographical and climatic conditions, as well as religious beliefs. Also, the supply chain for short-lived and perishable goods has always been one of the most important and challenging management issues at different times. Short-term supply of goods, especially foodstuffs, poses the greatest challenges to supply chain management. These challenges are mainly due to the special needs of tracking the flow of goods along the supply chain, the short life of products and the need for temperature control during different stages.

Reviewing the literature show that the blockchain contains information about price, location, quality, date and other product information. Supply chain management that uses blockchain in its price tracking system provides information to consumers in a transparent and reliable manner. This avoids the problems of corporate infiltration and unfair pricing. This technology has a high potential in eliminating intermediaries, which reduces costs and provides an organic product at more reasonable prices.

Perishable foods such as meat, fruits and vegetables are sensitive to environmental conditions. A key element for meat quality is its storage conditions, which can be seen by the blockchain. Blockchain with Internet of Things (IoT) can be better implemented in the perishable food supply chain. Blockchain technology, in connection with the IoT, makes food-related information such as storage temperature, ambient humidity more accurate, as well as GPS data in a non-manipulative and transparent way available to producers and consumers. Therefore, according to [33] because blockchain implementation is transforming organizations, a phasing strategy is recommended for implementation in meat supply chains [33].

Lack of manpower and skills is recognized as a major in blockchain challenge. In developing economies this shortage is more severe. Currently, due to the high cost and limited capabilities of blockchain, the use of blockchain-based solutions in high value food products is more realistic and justifiable than cheaper products [42]. One of the challenges of blockchain is the rules and regulations that exist in governments. Given that the acceptance of blockchain in this area is in its infancy, in order to successfully implement this technology and enjoy its benefits, it is necessary to cooperate more widely. The most common challenges of blockchain technology mentioned in the articles can be scalability (due to the time required to confirm transactions), energy consumption, transaction speed, lack of infrastructure (blockchain can only be used as long as the internet is available) and the necessary skills. The recurring benefits of this technology include the direct impact of blockchain on tracking, transparency, increased trust, authenticity, quality, food safety, and its indirect impact on cost reduction and efficiency. Also, according to the articles, traceability is one of the most important factors that lead to the acceptance of blockchain in this area. Transparency and authenticity of information are also important. Obstacles to blockchain acceptance include lack of awareness, lack of government regulation, and interoperability.

With the help of blockchain, food industry companies can significantly increase customer loyalty and sales growth. Getting out of the crisis and achieving profitability is important for food companies. Food retailers can easily identify the source and strategically remove contaminated products. In this case, the need to recall the entire production line is eliminated [42]. To increase consumer trust in food safety and improve security in food chains and consumer protection, traceability can be an effective tool [8]. Blockchain and related tracking capabilities can provide a complete audit trail of transaction data in a supply chain. Transparent, provable and immutable records are also added to the product pedigrees as digital certificates. Therefore, it helps to improve the traceability of supply chain networks [24]. One of the major measures for operational efficiency in supply chains and in the end the customer service has been identified as traceability [36]. It seems that due to increasing trust, transparency, customer loyalty and reducing costs, this technology has the potential to attract investment in these chains.

Based on the classification provided for articles related to the meat, fruit and vegetable supply chain, we found that a limited number of Prescriptive group research has been conducted. However, all the researches help to increase knowledge in this area. However, Prescriptive

studies identify underlying and solution-oriented problems and describe and analyze alternative courses of action in dealing with specific problems related to blockchain [40].

6. General Conclusions and Suggestions

The use of technology and information technology in various fields has led to a global digital transformation, and food supply chains are no exception to this rule. Blockchain technology has recently emerged as an anti-counterfeiting digital record in the food and agricultural industries. Despite the positive effects of this technology, little credible research has been done in this area. Given the number of review articles previously conducted in the field of food supply chain, the purpose of this article is to review the existing articles in this field and the components under study with a more comprehensive approach. This study provides a comprehensive picture of the current state of research in the food industry. It should be noted that review articles previously conducted in this area have examined the main drivers of blockchain deployment in the supply chain and identified areas where this technology may be most valuable. They have examined the challenges and benefits of blockchain in the tracking index as well as a content-based literature review on blockchain acceptance in the supply chain. Also, from a computational and practical point of view, the use of blockchain in the field of food products has been studied. Finally, the strengths, weaknesses, opportunities and threats of blockchain-based supply chain in agriculture are analyzed and the links between blockchain-based strengths on supply chain and sustainable development are examined. However, in a more comprehensive review, this study identified the key components of the articles that examined the effect of blockchain. Finally, we categorized the articles of these two chains into four groups: conceptual, predictive, prescriptive and descriptive. Therefore, in order to provide a better understanding of the process and type of research, we categorized the types of articles. Also, by presenting a graph, we have demonstrated the process of research during different years on the extracted components. In this article, we show the deep research gap that exists in the two supply chains of meat, fruits and vegetables. We tried to identify more research opportunities in this area. Although many of the challenges and benefits of blockchain in these two supply chains are still unclear, a systematic review of managers, academics, and researchers for innovation will help in future studies. This article examines the management approach of these two supply chains and does not consider the technical aspect. Further research is needed to find solutions to the challenges posed by blockchain, such as collaboration, coordination, and standardization of blockchains in different organizations.

In this article, in addition to reviewing the articles related to the use of blockchain in the food supply chain, the two supply chains of meat, fruits and vegetables have been examined in more detail. Most of the reviewed articles describe the many benefits of using blockchain in the food supply chain and the problems in the supply chain. Prominent supply chain problems mentioned in most articles include problems with tracking, information asymmetry, information fraud, lack of transparency, and high costs. Given the impact that the food supply chain has on people's health, the economy and its social impact, the need to handling these problems in this area is felt more than ever.

Meat, fruits and vegetables are the most used and important among consumers and these chains need more attention. Based on our literature review, we found that most of the researches in the agricultural and food sectors have been descriptive and needs to be investigated by the case studies. What is evident is the use of blockchain in two supply chains of meat, fruits and vegetables is in the experimental stage and this technology has not been used on a large scale. The point of acceptance and implementation of blockchain is in the meat supply chain of large meat providers. Providers compete on cost and are not interested in sharing their information. Therefore, by increasing their knowledge about private blockchains, they can be encouraged to implement this technology. In the fruit and vegetable supply chain, the retailer has a huge impact on the other actors in the chain and is referred to as the captain of the channel. Retailers in the fruit and vegetable supply chain have the ability to prevent the adoption of any technology. The starting point of blockchain in the fruit and vegetable supply chain is retailers. Finally, the condition for the implementation of this technology in these two supply chains is first to inform the stakeholders (producers, suppliers, farmers, retailers, etc.) of the effects and benefits of this technology. There is also a need for the interaction and cooperation of all different stakeholders, governments to implement the blockchain.

Based on the case study articles, we found that blockchain has been able to improve traceability, increase transparency, trust, authenticity, quality, safety, supply chain efficiency, and reduce information asymmetry in the food and agricultural industries. Also, in this group of articles on the positive effect of blockchain on selecting the right partners, selling products at reasonable prices, increasing customer satisfaction, increasing competitive advantage, reducing crop loss, establishing stable relationships, more efficient transaction management and the possibility of direct communication between different actors. Increased confidence in the purchase of the product is noted. It has also been stated that if the agreement has already been reached on product quality protocols, this technology will not affect product flow management and intrinsic product characteristics. One of the most important results from this literature review is that blockchain not only solves some technical problems but also has the ability to solve social and economic problems, but in the end this technology is not a panacea.

In researches, the most studied component is the tracking component. The tracking index has been examined for reasons of improving food quality, reducing safety problems, crop origin, real-time tracking, waste reduction, understanding the source with the aim of addressing contaminated sources, security, food authenticity and some others. In articles, the tracking index has been named as one of the most effective blockchain indicators in the food industry, which affects a large number of indicators. More empirical researches are needed on this index to examine more objectively the opportunities and limitations of blockchain. Tracking should be considered in terms of the various benefits it has to suppliers, retailers, consumers and manufacturers. According to what has been mentioned in other articles, the small number of case studies in researches indicates that the proposed theoretical and conceptual frameworks have been less applied in reality. Despite the positive theories about blockchain, it is possible that the results are actually different from theoretical research due to the distance between theory and application in practice. This survey does not fully identify the impact of blockchain on the meat, fruit and vegetable supply chain and the challenges that blockchain implementation may pose to these supply chains. In most research, permissionless (public) blockchains are examined. From the findings of some articles, we found that the choice of the right type of blockchain for the supply chain depends on a number of factors, including the supply chain goals to be achieved, the actors, and the issues they face. One of the best blockchains permissioned is hyperladger. In public blockchains, access to all people (lack of privacy protection) and identification of all to use blockchain in this area raises some doubts. In a food supply ecosystem, it is important to maintain a certain level of privacy because many factors compete with each other. But in authorized blockchains, access to privacy of transactions is provided only between selected individuals. Because some businesses still want to protect transactions themselves from unnecessary people, more researches should be done on the types of permissioned (private) blockchains and consortium and hybrid ones to get better conclusions about the use of permissioned or permissionless blockchains in food supply chains. Also, due to the tendency of some chains to use public blockchain and some private blockchain, cooperation and standardization between them is a challenge that we will face in the future. Another challenge is the quality of data entry into the blockchain. It is possible to inadvertently make an error entering the data entry that it is almost impossible to correct these errors.

In studies that have examined the component of validation and reliability, except for one article that used the consortium blockchain for security and privacy, the rest examined the general Ethereum blockchain and the smart contract. Of course, the Ethereum blockchain is receiving more attention due to the unlimited processing of these contracts. Implementing Ethereum blockchain and smart contracts poses challenges. First, what happens if an error occurs in the coding of these contracts and what problems it creates for the chain. Second, one of the benefits of an Ethereum blockchain and smart contract is independence and security, and it avoids any outside interference. How can governments be taxed to deal with smart contracts? Also, how can force others to behave honestly in smart contracts? Is the incentive and punishment mechanism responsive, as some have suggested? In these contracts, how is the audit control performed in cases of incorrect intent and distortion of information?

One of the goals of blockchain is to eliminate intermediaries, certainly intermediaries in the meat, fruit and vegetable supply chain will be very resistant to blockchain implementation. What will be done to prevent this resistance?

Naturally, there will be resistance to any change in any chain. It remains to be seen whether legislation and regulation by governments, raising awareness and cultivating forces and talents are sufficient to prevent these resistances to changes (For example, changing their existing revenue models) caused by this technology in the chains. As discussed in other articles, successful blockchain integration requires the participation of all participating organizations and stakeholders such as retailers, farmers, suppliers, and so on. As a result, it seems that the implementation of this technology is not easily possible. Despite all the benefits of blockchain (increased profits, reduced costs), it is unclear to what extent ranchers and farmers are willing to register their livestock and cultivation status in public in blockchain. Implementing it in countries requires infrastructures such as IT tools. This is a big challenge for developing and underdeveloped countries. A lot of effort is needed in these two chains to change the mentality of trust from a central institution to a decentralized network. Also, the standards of distributed offices for the organizations in each chain must be the same, otherwise it will reduce the effects of distributed offices. It is also not available with complete information about how much it can be successful in making farms smart and optimizing the supply chain. Improving data storage in this technology requires increasing computing power, which requires a lot of money and energy. The environmental and social threats posed by blockchain have been less studied. How to choose the best consensus algorithm for each supply chain and if each chain has a different algorithm, what is their compatibility and cooperation? Slow information processing, investment and complexity of blockchain based systems design, lack of formal roadmap for using this technology as a global tool for transactions, lack of common standards, possibility of conflicting its performance with government requirements, limited supply chain training platforms are the challenges mentioned in the articles.

We also found that very few components were studied in the two supply chains of meat, fruit and vegetables. These supply chains need more aspects and indicators such as the impact of blockchain on the pricing process, reducing fraud and contaminated food, food quality and security, reducing logistics time, the impact of process and transaction automation, smart contracts, supply chain coordination, investigate the transparency and supervision of monitoring organizations and reduce costs. Experimental research and exploratory research should be done with more case studies. There is little empirical evidence to assess the effects of blockchain on these two supply chains. There is also no deep understanding of blockchain among distributors, consumers, manufacturers, suppliers and retailers. Also, this technology has a high potential in preventing food waste and fraud in the field of food and agricultural industries, so it is necessary to conduct more extensive research in this field. It is particularly necessary to investigate the risk assessment arising from the evolution of this supply chain from the implementation of blockchain. Convincing farmers, ranchers and distributors, retailers in these two chains seems to be a big challenge to implement this technology.

In practice, blockchain is used in a limited number of countries. In developing countries facing problems with technology infrastructure and digital skills, blockchain implementation is expected to be limited in the next few years. Developing and underdeveloped countries need to increase their capacity to adopt and develop this technology in the food and agricultural supply chain. The digital divide that exists in underdeveloped and developing countries is a major challenge for the adoption of this technology. According to a review of the articles, we find that governments play a large role in accepting blockchain. Also, the high information symmetry and transparency achieved by this technology can greatly help countries whose national economies are based on food and agriculture.

More credible researches are need to be done on the environmental sustainability and impact of blockchain in this area. Also, the benefits of blockchain in logistics, transportation, reducing its time and its effects on environmental sustainability, should be studied from different aspects. Blockchain with its capabilities and features can be a good alternative to RFID technology and perform its tasks better and more efficiently, but along with IoT, it can provide more reliable tracking capabilities. Applying these two technologies together creates more benefits for the food industry.

The limitations of this research include the lack of valid and quality researches in this field, especially in the two supply chains of meat, fruits and vegetables. One of the potential limitations of this research is that it is conceptual.

We suggest that the future studies be conducted on the application of blockchain in agricultural

development, as well as on the impact of blockchain on the provision of organic products in the fruit and vegetable supply chain. Another suggestion for the future is empirical research to find more objective results on the elimination of local intermediaries and the farmer's direct access to the market with the help of blockchain features. Researches can be done on the effect of blockchain on improved performance evaluation component and cost reduction in the meat supply chain. Also, exploratory and experimental researches on the cooperation of big data and blockchain technologies in the two supply chains of meat, fruits and vegetables should be done and the high potentials of these two technologies in relation to each other should be examined. We currently need long-term blockchain projects in the two meat, fruit and vegetable supply chains with common standards for case studies.

The questions that arise at the end are:

How much does the lack of awareness of farmers, gardeners and ranchers affect the acceptance and performance of blockchain in these two supply chains?

To what extent does the incentive to achieve a sustainable competitive advantage motivate the acceptance of blockchain in the meat, fruit and vegetable supply chains?

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Appendix A.

Tab. 2. Review of research components in articles

year	Author	Traceability	Transparency and symmetry and information security	Logistics and removing brokers	Advantages and challenges of blockchain, its impact and application on the food and agricultural supply	Enhance visibility and trust or validity or reliability	Price and cost	The effect of blockchain on supply chain management or supply chain effectiveness	Authenticity and origin of food, quality,	Supplier problems in term of ledger or the effect of blockchain on the food	Safety or security and privacy	Barriers and factors of blockchain acceptance in the food supply chain	Motivations to purchase food with blockchain or prevent fraud	Case study
2016	Tian	✓	-	-	-	-	-	-	-	-	-	-	-	-
2017	Tian	✓	-	-	-	-	-	-	-	-	-	-	-	-
	Tse et al	-		-	-	-	-	-	-	-	-	-	-	-
	Sander et al	✓		-	-	-	-	-	-	-	-	-	-	-
	Osei et al	-	-	-	-	-	-	-	-	✓	-	-	-	-
	Bettin-Diaz et al	✓	-	-	-	-	-	-	✓	-	-	-	-	-
2018	Mao et al	-		-	-	-	-	-	-	-	-	-	-	✓
	Tan and yan et al	✓	-	-	✓	-	-	-	-	-	-	-	-	✓
	Malik et al	-	-	-	-	-	-	-	✓	-	-	-	-	-
	Kim et al	✓	-	-	✓	-	-	-	-	-	-	-	-	-
	Baralla et al	✓		-	-	✓	-	-	-	-	-	-	-	✓
	Hilt et al	-		-	-	-	-	-	-	-	-	-	-	-
	Mao et al	-	-	-	-	✓	-	✓	-	-		-	-	-
	Caro et al	✓	-	-	-	-	-	-	-	-	-	-	-	-
	Galvez et al	✓	-	-	-	-	-	-	✓	-	-	-	-	-
	Hayati and Nugraha	✓	-	-	-	-	-	-	-	-	-	-	-	-
	Lin et al	✓	-	-	-	-	-	-	-	-	-	-	-	-
	Kamath	✓	-	-	✓	-	-	-	-	-	-	-	-	✓

2019	Rejeb	✓	-	-	-	-	-	-	-	-	-	-	-	-	-
	Yeh et al	✓		-	-	-	-	-	-	-	-	-	-	✓	-
	Salah et al	✓	-	-	-	✓	-	-	-	-	-	-	-		-
	Tao et al	-	-	-	-	-	-	-	-	-	Food Safety Supervision System	-	-		-
	Madumidha et al	✓		-	-	-	-	-	-	-	-	-	-		-
	Yusuf et al	-	-	-	-	-	-	-	-	✓	-	-	-		✓
	Madumidha et al	-	-	-	-	-	-	-	-	-	-	-	-		-
	Mao et al	-	-	-	-	validity in transactions	-	-	-	-	-	-	-		-
	Creydt and Fischer	✓	-	-	-	-	-	-	-	-	-	-	-		-
	Musah et al	-	-	-	-	-	-	✓	-	-	-	-	Prevent fraud		-
	Mezquita et al	-	-		-	-	-	-	-	-	-	-	-		-
	Scuderi et al	-		-	-	-	-	-	✓	decrease the distance between p and c	-	-	-		-
	Chan et al	✓		-	-	-	-	-	-	-	-	-	-		-
	Mondal et al	-	-	-	-	-	-	-	-	-	FSC monitoring architecture	-	-		-
	Antonucci et al	-	-	-	✓	-	-	-	-	-	-	-	-		-
	Ehmke and Ehmke	✓	-	-	✓	-	-	-	-	-	-	-	-		-
	Longo et al	-	-	-	✓	-	-	-	-	-	-	-	-		✓
	Tsang et al	✓	-	-	-	-	-	-	-	-	-	-	-		✓
	Baralla et al	✓	-	-	-	-	-	-	-	-	-	-	-		-
	Kshetri	-	-	-	-	-	-	-	-	-	✓	-	-		-
	Lin et al	Safety Traceability	-	-	-	-	-	-	-	-	-	-	-		-
	George et al	quality traceability	-	-	-	-	-	-	-	-	-	-	-		✓
	Yildizbasi and Ustunyer	-	-	-	-	-	-	✓	-	-	-	-	-		-
	Kamilaris et al	-	-	-	✓	-	-	-	-	-	-	-	-		-
	Bechtsis et al	-	-	-	Blockchain Framework for Food Supply Chains	-	-	-	-	-	-	-	-		-
	Casino et al	✓	-		-	-	-	-	-	-	-	-	-		-
	Zhao et al	-	-	-	-	-	-	Improve food nutritional value chain management	-	-	-	-	-		-
	Meidayanti	✓		-	-	-	-	-	-	-	-	-	-		-

	et al																
	Maghfirah	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Jarka	-	-	-	-	-	-	✓	-	-	✓	-	-	-			
	Pearson et al	✓	-	-	-	-	-	-	-	-	-	-	-	-			
	Basnayake and Rajapakse	-		-	-	✓	-	-	-	-	-	-	-	-			
	Chandra et al	-	-	-	✓	-	-	-	-	-	-	-	-	-			
	Shakhbulatov et al		-	-	-	-	-	-	-	-	-	-	-				
	Casino et al	tracks the carbon	-	-	-	-	-	-	-	-	-	-	-	-	✓		
	Machado et al	improving safety and scientific traceability of	-	-	-	-	-	-	-	-	✓	-		-	-		
	Yadav et al	-	-	-	-	-	-	-	-	-	-	✓	-	-	-			
	Duan et al	-	-	-	-	-	-	-	-	-	-	✓	-	-	-			
	Chen et al	-	-	-	✓	-	-	-	-	-	-	-	-	-	-			
	Feng et al	✓	-	-	✓	-	-	-	-	-	-	-	-	-	-			
	Hew et al	✓	-	-	-	-	-	-	-	-	-	-	-	-	-			
	Mirabelli and Solina	✓	-	-	-	-	-	-	-	-	-	-	-	-	-			
	Rogerson and Parry	-	-	-	-	✓	-	-	-	-	-	-	-	✓	✓		
	Ahamed et al	-	-	-	-	-	-	✓	-	-	-	-	-	-	-		
	Ferdousi et al	✓	-	-	-	-	-	-	-	-	-	-	-	-			
	Ferrag et al	-	-	-	-	-	-	-	-	-	✓	-	-	-			
	Tipmontian et al	-	-	-	-	-	-	✓	-	-	-	-	-	-			
	Chopra	✓	-	-	✓	-	-	-	-	-	-	-	-	-			
	Fu et al	-	-	-	-	-	-	✓	-	-	-	-	-	-	✓		
	Dong et al	✓	-	-	-	-	-	-	-	-	-	✓	-	-			
	Ray et al	-	-	-	✓	-	-	-	-	-	-	✓	-	-			
	Stranieri et al	-	-	-	✓	-	-	-	-	-	-	-	-	✓			
	Bumblauskas et al	-	-	-	-	-	-	-	-	-	-	-	-	✓			
	Amin et al	-	-	-	-	-	-	Enhanced Blockchain Transaction and management supply chain	-	-	-	-	-	-			
	Kumar et al	✓		-	-	-	-		-	-	-	-	-	-			
	Kamble et al	-	-	-	-	-	-	-	-	-	-	✓	-	-			
	Pena and Llivisaca	-	-	-	-	-	-	✓	-	-	-	-	-	-			
	Iftekhar et al	✓	-	-	-	-	-	-	-	-	✓	-	-	-			
	Shahid et al	✓	-	-	-	✓	-	-	-	-	-	-	-	-			
	Prashar et al	✓	-	-	-	✓	-	-	-	-	✓	-	-	-			
	Waqas Khan et al	-	-	-	-	-	-	✓	-	-	-	-	-	-			
	Zhang et al	-	-	-	-	-	-	-	-	-	✓	-	-	-			
	Patelli and Mandrioli	✓	-	-	-	-	-	-	-	-	-	-	-	-			
	Abidin and Perdana	-	-	-	-	product verification	-	-	-	-	-	-	-	-			
	Dey et al	-	-	-	-	-	-	-	-	✓	-	-	-	-			
2020																	

	Tiwari	✓	-	-	✓	-	-		-	-	-	-		-	-	-
	Behnke and Janssen	✓	-	-	-	-	-		-	-	-	-		-	-	✓
	Motta et al	-	-	-	✓	-	-		-	-	-	-		-	-	✓
	Fan et al	✓	-	-	-	-		✓	-	-	-	-		-	-	-
	Baralla et al	✓		-	-		✓	-	-	-	-	-		-	-	✓
	Kohler and Pizzol	-	-	-	✓	-	-		-	-	-	-	-		-	Objective cases
	Kayikci et al	-	-	-	✓	-	-		-	-	-	-	-	-	-	-
	Pawar et al	-	-	-	✓	-	-		-	-	-	-	-	-	-	-
	Xu et al	-	-	-	-	-	-		-	-	-	✓	-	-	-	-
	Tan et al	✓	-	-	-	-	-		-	-	-	-	-	-	-	✓
	Lin et al	✓	-	-	-	-	-		-	-	-	-	-	-	-	-
	Saurabh and Dey	-	-	-	-	-	-		-	-	-	-		✓	-	-
2021	Cao et al	-	-	-	-	Strengthen trust in traceability	-		-	-	-	-	-	-	-	✓
Total 2016	-	1	0	0	0	0	0		0	0	0	0	0	0	0	0
Total 2017	-	1	1	0	0	0	0		0	0	0	0	0	0	0	0
Total 2018	-	11	4	0	3	3	0		1	3	1	2	0	0	4	4
Total 2019	-	14	6	1	6	2	0		4	1	2	4	0	2	4	4
Total 2020	-	18	2	0	10	5	1		7	0	1	6	5	1	10	10
Total 2021	-	1	0	0	0	1	0		0	0	0	0	1	0	1	1
Total	-	46	13	1	19	11	1		12	4	4	12	6	3	19	19

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