

Analysis of Food Supply Chain Process by Block Chain Based Approach

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Abstract— The developments in technology and the emergence of new technologies have increased the expectations for the supply chain to have a more efficient, traceable and transparent structure. Although the legal regulations and standards of blockchain technology have not been clearly revealed yet, it is thought that it will solve many problems with its application in the food supply chain. In this context, the use of blockchain technology in the food supply chain, its advantages and disadvantages and today's application examples were examined by making a literature review. As a result of the study, it has been seen that blockchain technology provides significant added value to the food supply chain and is a solution to many problems of today's traditional supply chain.

Index Terms— Auditability, blockchain technology, food supply chain, traceability, transparency.


I. INTRODUCTION

THE CURRENT supply chain is a linear business model. However, increasing international competition and increasing outsourcing with globalization increase the number of members in the supply chain day by day [1]. Depending on the situation, the supply chain process of a product may include multiple international borders, different state and customs processes, many invoices and payment stages, as well as multiple individuals or institutions, and comprehensive and multidimensional transactions that can take months depending on the nature of the transaction. All these complexities negatively affect performance and increase risks in the supply chain. Delays in transactions, increased costs, loss of trust between the parties are some of the prominent risks [2].


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In addition, the confidence of consumers was shaken in the food safety crisis that emerged with the increase of food-related problems. According to the World Health Organization [3], food safety is one of the most important causes of the most common health problems in the world. Therefore, consumers want to be aware of every process from the production to consumption of the products. This situation causes consumers to prefer businesses where they can track food.

First of all, it is thought that blockchain technology, which has found an application area in the field of finance, will lead to important solutions in many areas. There is no need for a third party for transactions made with this technology. As each transaction takes place, it is processed into the encrypted block by the supply chain member performing that transaction. Each block is linked to previous and next blocks and cannot be changed or deleted by a single chain member. With the blockchain, which is an autonomous technology, transactions can be made automatically by connecting to conditions.

The decentralized nature of the blockchain increases its validity by providing control over the change of information. In addition, thanks to this distributed structure, an error is not collected in a single point and attacks on the network are prevented. However, this digital ledger, which is not guaranteed by any third party, required measures to be taken on important issues such as the risk of users cheating. For this reason, all transactions are processed into the public ledgers of computers that hold an identical copy of each ledger, giving the entire network the power of surveillance. These ledgers are constantly updated when users make their transactions [4].

This nature of blockchain is seen as a potential solution to many problems in the supply chain. With a blockchain-based structure, every changeover of a product from manufacture to sale can be documented, creating a permanent product history. In this way, it may be possible to significantly reduce time delays, additional costs and human errors that hinder today's operations. By using smart contracts, automated control and action flows can be realized during the movement of a product on the chain (such as transferring Z units of money after a product reaches stage X and passes Y control). When we evaluate it from the perspective of the customer, users can be informed about the arrival process of the product they bought and make a more conscious decision.

The aim of this study is to reveal what kind of gains can be achieved by applying blockchain technology to the food supply chain, what obstacles will be encountered and for what

purposes it is used. For this purpose, in the first chapter, the definition of supply chain and the analysis of the main problems such as the difficulty of traceability of today's supply chain processes, lack of trust and lack of coordination between the parties are given. In the second part, what is blockchain technology and its uses in the food supply chain are mentioned. In the third chapter, the advantages and disadvantages of Blockchain technology in a supply chain area are discussed. In the fourth chapter, the supply chain applications of blockchain technology in the field of food are given. In the last part, there is the general evaluation and conclusion part.

II. SUPPLY CHAIN

A. Supply Chain and Supply Chain Management

The supply chain can be defined as a chain that connects all the links (suppliers, production centers, warehouses, distribution centers, retailers, etc.) from the raw material supply to the end users [5] as shown in Figure 1. The supply chain is a dynamic process that includes the continuous flow of materials, funds and information across many functional areas. In other words, a company's supply chain; raw material producers convert raw materials and semi-finished products into finished products. In other words, they are all the elements that create value during the manufacturing processes, and then during the delivery of the finished products to the final consumer in the distribution channels [6]. These processes rely on rules, trust, and security provided by third parties that manage this flow [7].



Fig.1. Supply Chain Process

B. Functioning and Basic Problems of Today's Supply Chain

With the globalization of today's supply chain, many people, companies and institutions become parties to the supply and logistics operation processes, the documents in the transactions are many in variety and number, they include more than one country and each of these countries has different legal rules. Since it is difficult to trace transactions and documents, it causes both high cost, confusion and time loss due to reasons such as loss of documents and the risk of creating fake documents. In addition, the payments between the parties take days and as the products pass through various countries and regions until they arrive at the destination, the traceability of the products becomes difficult as documents can be lost and counterfeited.

The history of traceability dates back to the early 1930s, when some European countries wanted to prove the origin of

high-quality foods such as French champagne. Traceability is a complex issue as it requires the involvement and collaboration of actors throughout the entire supply chain to track a product's history. In practice, chain traceability can be achieved if businesses keep records of their suppliers and customers and share this information with every member along the entire supply chain. Traceability is used to improve food safety, use in quality control activities, fight fraud and manage complex chains. For example, the traditional model of a supply chain starts with the manufacturer and importer as shown in Fig. 2. The next stage is the exporter, manufacturer, and wholesaler. This stage is the intermediate stage that processes the basic products. The last stage is retailer. In summary, there is a linear model in the traditional supply chain from manufacturers and importers to retailers. The disadvantage of this model is that the consumer does not have

Although the structure of the supply chain varies widely from company to company and from industry to industry, it can be seen in both service and manufacturing organisations. The supply chain structurally begins with the purchase and acquisition of the goods to be sold. It then turns to inventory management and warehouse management to support sales. It ends with the delivery of the products to the customers [8]. But that has changed with the boom of the internet, technological innovation, and the global demand-driven economy. Today's supply chain is no longer a linear as in Figure 1. It is a complex structure [9] consisting of different networks that can be accessed 24 hours a day. At the heart of these networks are consumers who demand that their orders be fulfilled when and how they want it. When, where, how and in the desired quantity, the orders are delivered to the customer in a cost-effective way has become a success method [10]. What is important in supply chain management is the correct planning of activities such as stock levels, supply and demand balance, cost and asset management, cash flow, production and logistics. Therefore, every company should work with a suitable supply chain strategy and design.

Effective management of the supply chain ensures increasing customer satisfaction, reducing the cycle time (from receiving the customer order to the manufacturer to collect the customer's payment), reducing inventory-related costs, and reducing product errors. It should be organized in a way that has sufficient information sharing, roles and responsibilities, and reporting relationships defined [11]. The importance and complexity of supply chain management is increasing exponentially due to the increasing number of customers with increasing demands and increasing competition in the market.

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a method of verifying the production and distribution stages of the food to be purchased.

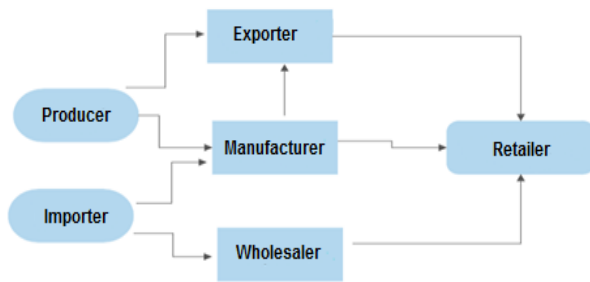


Fig.2. Traditional Supply Chain

Since the process is not transparent, the fact that the buyers know the origin and value of the products makes it difficult to determine whether any fraudulent or illegal transaction was committed, by whom, when and where, that is, the responsible person. In addition, the lack of transparency causes a lack of trust between the parties. Trust in the supply chain is defined as the willingness to believe in business partners that can be trusted. Effective supply chain planning based on information sharing and trust among chain members is one of the most fundamental elements of successful supply chain practices. In supply chain relations, trust and risk issues are of great importance, since there is a high degree of independent action between companies within the chain. In addition, trust is considered as an important asset that increases the performance of the companies involved by increasing cooperation, reducing transactions and costs, facilitating market transactions, and improving the ability of companies to keep up with complex and uncertain environments [12].

Another problem in supply chain management is the lack of coordination of activities between the parties. If this problem is solved, businesses will gain benefits such as "reducing costs, increasing service level, using resources more effectively and reacting faster and more efficiently to changes in the market" in supply chain processes [13].

III. BLOCKCHAIN TECHNOLOGY

Although there is no single agreed definition of blockchain technology, in the most basic terms, it is managed by many computers called nodes, which is not under the control of a single person or organization, uses hashing algorithms for verification of transactions and consensus protocols for approval, sorts transactions with timestamp, and is approved. It is a distributed data recording system that keeps an identical copy at all nodes by linking transactions one after another with cryptography and hashing functions, and the data it contains is almost impossible to change and reverse [14].

This word first came to the fore with Satoshi Nakamoto's concept of Bitcoin in 2008. In fact, in Satoshi Nakamoto's article (Nakamoto, 2008), the term "blockchain" is not used directly, while the system is described as the building block where the transactions are recorded, and the addition of each approved block to each other with a special algorithm is expressed as a chain, and then it has been used as a blockchain [14]. The blocks in the blockchain are connected to each other linearly and chronologically [15]. In each block, there is the block order, the block title summary, the summary of the title of the connected and previous block, the time stamp of the time the block was created, the random value and the values of the transfer operations as represented in Fig. 3.

One of the most important characteristics of blockchain is its distributed and shared structure. Therefore, blockchain-based systems have the potential to eliminate costs and conflicts caused by existing intermediaries. Thus, it promises more data integrity, distribution, an environment of trust that does not require intermediaries, and lower transaction costs [16].

We can say that blockchain technology has experienced two revolutions in its history so far; Bitcoin and Ethereum. Bitcoin is the distributed form of the technology called Blockchain 1.0, which provides only data recording and security. In this way, it provided important developments in the financial sector.

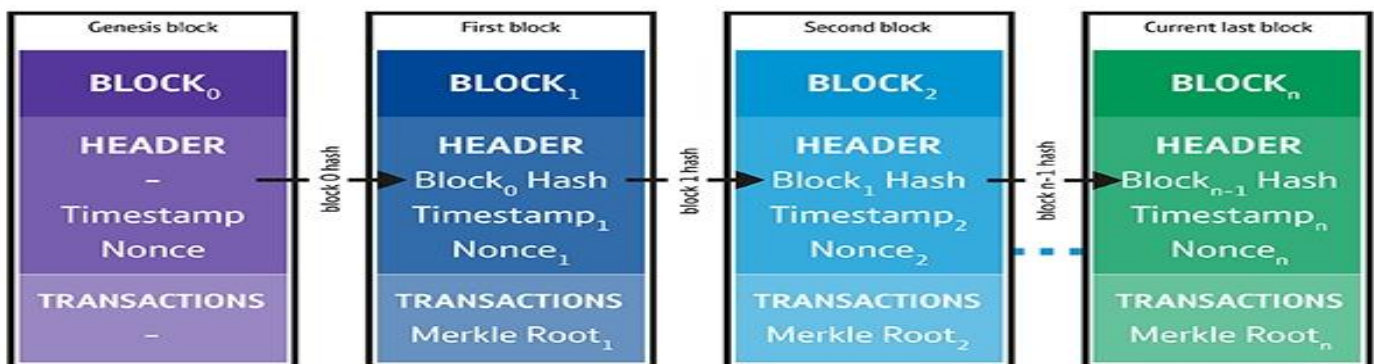


Fig.3. Blockchain Structure [17]

Ethereum, on the other hand, is a platform called Blockchain 2.0, created with the blockchain infrastructure within the framework of Vitalin Buterin's smart contract concept. The reason why Ethereum is so important; It is both an easy-to-apply and a reliable platform for smart contracts, which date

back to pre-blockchain technology. Smart contracts have smart contract accounts like blockchain accounts [18].

The system verifies that every node included in the contract complies with the terms of the contract as a result of coding the details of the information such as the algorithms to be

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implemented by the contract and the calculations to be made and uploaded to the Ethereum website. It is very important that the contract is prepared correctly and completely. Otherwise, as in the project called DAO, a user can take advantage of any vulnerability of the smart contract and transfer the money in the contract account to another account [19].

A. Use of Blockchain Technology in Supply Chain

The transparent structure and cryptology feature of the blockchain technology and the decentralized structure of the information flow between the parties offer important opportunities for trust and full-time communication. It offers radical solutions to the problems of miscommunication and product history in the traditional supply chain. With the participation of all supply chain stakeholders in the blockchain network, it is possible to document the permanent and secure product history from raw material to the final product [18]. Necessary notifications reach all rings of the supply chain thanks to the full-time information flow. In this way, a perfect balance of supply and demand is formed.

With blockchain technology, in order to prevent food-related health problems and to renew the consumer's trust in food businesses, it is possible to monitor the processes and conditions of food in the supply chain process, control of the additives and chemicals used, detection of contamination levels, and thus traceability from field to fork [20]. This traceability is done through the radio frequency identification (RFID) tag, QR code, barcode, GPS tag, chip of the internet of things technology. It is one of the important advantages of this technology to monitor every movement from production to sales, to observe the process transparently by consumers, and to prevent imitation and adulteration because food product information cannot be changed [21]. In addition, many food safety problems such as the horse meat scandal, salmonella in eggs, listeria in cheese, E. coli 0157:H7 in hamburgers and food counterfeiting reveal the importance of traceability. In such a food safety issue, the parties in the chain can see where the harmful substances come from, batch numbers, factory and processing data, expiration dates, shipment details and which stores they are delivered to, thanks to blockchain technology [26]. To give an example, Migros supply chain security and transparency [22]; Walmart, food product history and certificates; Provenance, tracking all kinds of food materials from production to consumption; Everledger, wine movements and warehouse information [23]; jd.com uses blockchain technology to track the entire retail process in the fight against fraud.

Another area of use is to prevent losses in perishable food resources. For example, although our country ranks first in the

world in vegetable and fruit production, serious losses are experienced during transportation and marketing, as well as decay and deterioration. In order to detect and prevent these losses, it will be possible to monitor the processes from the harvest of vegetables and fruits to their storage, distribution and sale to the customer.

The delay in payments in the supply chain is one of the most important reasons for the bottleneck in the process. Thanks to the smart contracts in blockchain technology, it contributes to the acceleration of financial money transfer transactions of international enterprises, reducing transaction costs and eliminating the risk of fraud [24, 25].

A lot of paperwork is done during the shipping process. These processes cause both time and money loss. It is estimated that the cost of processing documents related to the trade made accounts for 15 to 50 percent of the physical transportation costs. For example, many businesses still use printed bills of lading on paper. This situation creates the need for a department that organizes the documents within the organizational structures of the logistics service providers and the personnel working there. The existence of bill of lading or documentation departments will also come to an end, as the need for printed documents will be eliminated with the blockchain [26, 27].

Smart contracts are computer programs that determine the rules of the blocks that will be formed in the Blockchain. Smart contracts are the determination of the necessary rules and laws in the network infrastructure to be established and this is seen transparently by all participants [28]. As seen in Figure 4, the application process consists of four parts: physical flow, information flow, blockchain and smart contract. On the physical flow side, there are the stakeholders of the supply chain. There is a flow of information between stakeholders in every supply chain. Throughout the supply chain, each stakeholder records information in blocks in the blockchain. These blocks are connected with each other and turn into a chain that includes all the tasks done up to the end of the supply chain, all the stakeholders involved and information specific to a customer. Smart contracts are created by automatically filling in agreed-upon contracts using information found in a blockchain. In smart contract, on chain It is not possible to make any changes without the agreement of the parties involved. For example, a payment is automatically made after all contractual terms for a delivery that has already occurred (eg quantity, quality, timing, etc.) are met [25].

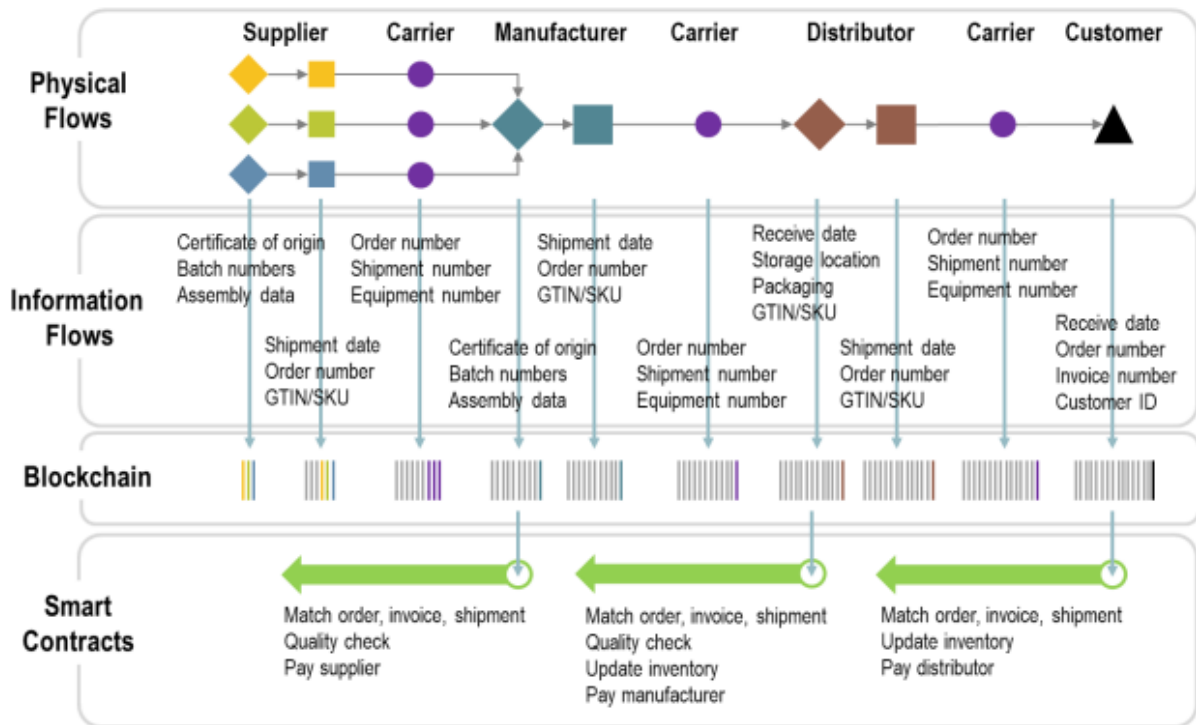


Fig.4. Blockchain applications in the supply chain [25]

IV. ADVANTAGES AND DISADVANTAGES OF USING BLOCK CHAIN IN SUPPLY CHAIN

The use of blockchain technology in the supply chain has many advantages. The first of these is security. Security is at the highest level. Due to the structure of the blockchain, the records cannot be changed, the data is verified multiple times and uploaded to the system upon agreement of all parties.

With the digitization of document transfers and the acceleration of data flow, it provides efficiency and cost advantages, especially in cross-border activities. Considering an activity consisting of tens of people and organizations in more than one country, such a high rate of error and delay is high and records need to be reproduced many times.

Another advantage is that it provides traceability. For the quality and safety of the products, it is possible to trace them throughout the supply chain from field to table. In this way, it is ensured that consumers consume reliable, transparent, traceable and quality products, thus eliminating the food safety concerns of consumers.

Blockchain also bridges the gap between small sellers and large sellers. According to IOHK director of product Aparna Jue, small coffee farmers in countries like Ethiopia may lack the capital to invest in the traceability solutions needed to complete traceability from source to source. In this case, it is unlikely that small coffee farmers will be selected as suppliers to multinational companies. Therefore, only a few large suppliers dominate the market. By using blockchain in industries like coffee and agriculture, all farmers can access traceability solutions with their GPRS-enabled mobile phone, eliminating notorious intermediaries. This enables SMEs to be

secure and transparent, supporting large supply chains and economic growth [29].

After the second step in the supply chain, tracking becomes difficult. Difficult to follow-up causes many details to be overlooked and security vulnerabilities such as theft, smuggling, loss, and counterfeit product transportation.

Since the supply chain includes multiple processes and processes, problems such as loss of documents and misarrangement may occur, no matter how careful attention is paid. Thanks to the smart contracts of the blockchain technology, such problems are reduced as the processes do not require any manual operations. In addition, high paperwork costs and the need for paperwork personnel in the supply chain process are avoided.

Another advantage is that, thanks to smart contracts, human-induced errors are minimized, as processes normally performed by humans are performed automatically. In addition, problems such as loss of documents and incorrect arrangement of documents are eliminated.

Thanks to the smart contracts in the blockchain technology, payments can be made faster, transaction costs are lower and the risk of fraud is eliminated.

Blockchain also bridges the gap between small sellers and large sellers. Aparna Jue, IOHK product director, said: "Considering the coffee industry, small coffee farmers in countries like Ethiopia, for example, may lack the capital to invest in the traceability solutions needed to complete traceability from source to source. But this is not the case for larger coffee producers, who not only have access to more resources but also the latest technologies. While larger farmers can use these systems to secure certificates for the sustainability, traceability and validity of their coffee beans, smaller farmers lack access to the technology needed to keep

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these records. Small farmers are unlikely to be selected as suppliers to multinational companies without this information. Therefore, only a few large suppliers dominate the field. Using blockchain in industries like coffee and agriculture, all farmers need access to traceability solutions. With a basic GPRS-capable cell phone of the kind that has been around for 20 years, farmers can become part of a global network. Blockchain enables the transportation and traceability of their products via a phone app, eliminating notorious middlemen. This enables SMEs to be secure and transparent, supporting large supply chains and economic growth.” [30].

Moreover, it is not dependent on a central authority. This allows transactions to run faster and costs to be lower. However, this advantage also paves the way for disadvantages. Because this system, which works without being tied to a place, can be configured in different ways for different purposes by various software developers. This means that the chains are not standard and if the chain members have any problems, they cannot be solved easily because there is no interlocutor. This is the main reason why investors are more cautious about blockchain applications [29].

One of the obstacles to the use of blockchain technology is how well it will be accepted in the supply chain industry. Because there are obstacles such as the fact that the stakeholders are at different levels in terms of compliance with blockchain technology, the stakeholders do not want to abandon their past habits, the material and moral burden of adapting to technology and changing the way of doing business is high, compliance problems between stakeholders, and legal differences between countries.

The difficulty of understanding this technology is also an important obstacle to the use of blockchain technology. Because to understand blockchain technology, it is necessary to have the working principle, system and security knowledge of the blockchain. Therefore, stakeholders should receive training in these areas [31].

Another obstacle to the use of blockchain technology in the supply chain is that the relevant legal regulations are still in the preparation stage. Issues such as the legal binding and infrastructure of smart contracts, whether records in the blockchain can be accepted as evidence are also disadvantages of blockchain technology.

Since the blockchain includes all records from the first transaction, the scalability problem arises as the size of the registry grows over time. In addition, transactions can be made in a certain way per second in the blockchain. As the number of participants in the blockchain increases, the number of transactions will naturally increase, so the response time to transactions will increase.

The fact that the blockchain technology is not yet technologically mature and does not become a standard application is another obstacle to the use of this technology. In addition, high development costs and the possibility of failure of startups are barriers to the use of blockchain technology. Because if the attempt is unsuccessful, it will cause loss of both money and time.

In addition, since the blockchain is a new technology and has decentralized autonomous organizations, authorization problems are of great concern, and in case of a data breach or

legal dispute, the question of who will be held legally responsible and how to deal with the regulations and laws related to the limits of authority comes to mind [32].

V. FOOD SUPPLY CHAIN APPLICATIONS OF BLOCK CHAIN TECHNOLOGY

A. *Transparent Path*

The Transparent Path platform displays the food journey from farm to consumer in real time. It allows companies to manage food safety and research the origin of food. This platform combines sensor technology, third-party auditors and decentralized blockchain applications to provide a transparent real-time view.

B. *TE-FOOD*

It is the world's largest public blockchain-based farm-to-table food tracking system used by Migros, Switzerland's largest grocery chain. With the application of TE-FOOD, transparency is provided for Migros customers. How does this blockchain system work? Suppliers are required to enter data into the Electronic Product Code Information Service (EPCIS). Information added to the EPCIS system is added to Migros' blockchain network. Finally, consumers who scan the QR code can access detailed information about the products, just like Carrefour and Walmart.

C. *Ripe.io*

It offers enterprise blockchain technology for the food and agriculture industry to create greater trust and transparency between food manufacturers, distributors and customers. By making use of sensor data, the data of the source of the food is processed into a blockchain-based system, providing transparency from field to fork. It is a technology platform where everyone from the producer to the distributor is involved, contributes to data and follows the journey of food.

This blockchain technology platform was first used to grow tomatoes. By collecting farmer data and information about temperature, humidity and tomato chemistry from sensors, it is aimed to grow better tomatoes. In this way, farmers will be able to meet market demand effectively and produce high quality, sustainable products. In addition, distributors will be able to monitor the process effectively and receive real-time information about food safety and delivery, while consumers will be able to monitor the stages of the product they purchase throughout the supply chain.

D. *CBH Group*

Australia's largest grain producer, CBH Group, has begun trials to use blockchain technology for shipping its products. Grain growers' cooperative has started to use a blockchain-based system in order to track the origin of the grain from the producers and document its quality. The main purpose of the system to be used is to show the data in the supply chain to potential buyers and to increase the trust in grain warehouses [33].

E. AgriDigital

The AgriDigital initiative was established in 2015 and emerged in agricultural supply chains. It was established to solve emerging problems on a blockchain-based basis. The company's main field of activity is in grain supply chains, but in the fields of rice and cotton industry is also working.

AgriDigital supports grain producers, buyers, wholesalers, intermediaries, shippers and agricultural on a single platform using blockchain technology brings together. Thus, stakeholders can make smart contracts over this structure, can carry out delivery and payment transactions instantly. A cloud-based application Besides, AgriDigital operates using blockchain protocol layers. While establishing AgriDigital, in order to find solutions to the agricultural problems given below developed.

- Inability of farmers to receive their payment as soon as they deliver their products,
- Inability of buyers to have sufficient financial resources during the procurement of agricultural products,
- Investment due to the inability of investors to monitor and control the supply chain abstain from,
- Since consumers do not know where the food comes from and under what conditions, anxiety in purchasing transactions [34].

F. Provenance

Thanks to the online platform that the company has established, information among its customers enabling them to change. Transparency between partners in information sharing is important although it is open to those with authority, it cannot be changed. The most important application The aim is to verify the origin of the product, especially in the field of food, and to ensure that the fake use of certificates precedes it. Thus, the traceability of the products will increase and the brands will achieve the desired quality attachment will be achieved. Provenance's data solutions, by tagging with smart tags it can be integrated into any physical product online or via mobile application. For example, which supply chain does Indonesian tuna fish from the shore to the end consumer? It has been successfully followed that it has gone through all stages [34].

VI. CONCLUSION

The supply chain is a whole consisting of the stakeholders involved from the production of a product to reaching the consumer. The supply chain can be very simple in structure as well as very complex and complex. Today's supply chain management structure cannot be a solution to the problems of this complex and complex structure. Blockchain technology is thought to be a solution to many of these problems.

In this study, the advantages and disadvantages of blockchain technology, which has applications in many sectors, especially in finance, if it is applied to the food supply chain, for what purposes it can be used and application examples are emphasized. It has been seen that it will provide significant added value. However, although it has become popular today, more research is needed on the application of

blockchain technology in the food supply chain. In addition, since Blockchain technology has not yet completed its technological competence and due to its complex nature, a detailed analysis process is required before it can be implemented.

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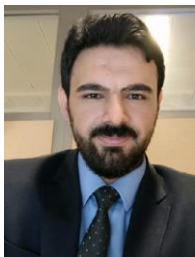
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