# Applications and Challenges of Blockchain with IoT in Food Supply Chain Management System: A Review

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**ABSTRACT**

Food security has become the most important thing now a days. People are getting infected by food coming from unprotected sources. Many technologies have been developed for this problem but a very successful technology is blockchain due to its nature of decentralization and transparency which helps in protecting food. Blockchain protects the food and also trace the source of the food from where it came without involving third party. According to present studies blockchain still needs more advancement. This paper carries out the systematic literature review based on the applications and challenges of blockchain in food supply chain management combined with IoT to provide more transparency, traceability and transparency with pros and cons. Our study indicates few barriers and challenges in the safety of food which are still existing in food supply chain management and faced by people now a days all these challenges have been discussed in this paper. This comprehensive literature review provides a useful perspective on many issues of food supply chain without blockchain.

*Keywords: Blockchain, Food Chain, Food supply chain management, Food traceability, IoT.*

## 1. INTRODUCTION

Blockchain is a very advance technology which almost making place in very field of life and has made everything easy for us [40-43]. People are getting benefit by using blockchain and saving time and money also. As we know that, food safety has become very important and complex as well. Consumers are concerned about good quality of products and safety of the food and also want to know the source of the food either it comes from a trustable source or not. So, many cases of food problems have been noticed and frauds about food chain is the major concern of these days. Due to the shortage of money people are taking wrong routes to get money and they are involving themselves in every harmful activity without thinking about others health or life [1].

According to World Health Organization (WHO, 2015) 1 people out of 10 is getting food disease every year. Many food scandals faced by many companies [10]. Almost 2 million people losing their lives due to diseased water and food. All these problems make everyone concern about food quality and safety. So many people no more agree with the food items and their data offered at the general stores, yet additionally look for the security that what they purchase comes from solid sources and that there is no mistiness or altering in the item data [32-39]. Since this has become a fundamental worldwide issue, constructing a food supply chain traceable framework is getting increasingly critical [2], [3]. Food safety is now a major challenge for people living at far distance from each other and wants to purchase food from a source far away from them. It's not about the customer or consumer who is worried about purchasing any food item but also companies are more concerned about dealing with any other company regarding food selling. So many companies have faced losses in dealing with others at distance. Therefore, companies are making their reputation their priority and do not want to make any wrong decisions about food dealing. Every consumer is expecting to have best quality food and every company or seller also wants to sell the best food so no harm could be faced by anyone. Therefore, food supply chain management should take strong precautionary measures to this problem [2]. Blockchain makes this easy by not involving any third party due to decentralized nature of blockchain everybody could be able to interact directly

and also make it secure by not removing anything from the history of food chain permanently regarding food and payment. Main purpose to write this paper is to address the problems faced by people in food supply chain management which needs to improve [8].

The main aim of my study is to address the success of blockchain in food supply chain management. Many studies have been conducted to solve the problem of food supply as we know everyone worried about their health and taking serious precautions about it. Food supply chain has been more secure by implementing blockchain but now with the advancement of technology it become more secure. Blockchain with IoT solved many complex problems and many studies provided this solution. Lastly, pros and cons of this combination of blockchain with IoT have been discussed.

This paper has been divided into five sections. First section I present introduction of this paper. Second II section presents the research methodology in which questions have been designed according to the problem. Section III includes literature review of selected research papers on blockchain technology. All questions have been answered in this section according to the study. In section IV and V, challenges and applications of blockchain technology have been discussed and includes conclusion.

## 2. RELATED WORK

Blockchain technology have been a best approach to make food secure in food supply chain. Many researches have been provided to address this issue of food safety in supply chain management. Now blockchain with IoT made this easier for managing the safety of food. This literature reviews provided blockchain with other technology to make sustainability in food chain.

In 1997, Food supply chain was established by Flkerts and Koehorse. Many companies worked harder to develop a large food chain and food items, to figure it out predominant client esteem at the most reduced potential expenses. Contrast with different organizations, food items have more weak value chain, and require more consideration over taking care of measures [10], [11]. The characteristic element of changing quality all the time make keep food wellbeing and quality a test. External conditions, for example, temperature and transports can likewise contribute to influence items quality and newness. Plus, complex food supply chain additionally implies higher dangers of items disappointment, which incorporates food borne infection, food harming, low quality food, fake items, or mislabelling and undeclared fixings after delivering [17],[18].

Twenty-one journal and conference papers with 89 or more publications have been included in this literature paper. Top 10 papers include supply chain and food

security with blockchain and other 15 papers also include IoT and future challenges of food processing. Our study shows the interaction of both technologies to make food chain more secure. Absence of transparency can cause certain dangers include: data disparity between partner, pay off, data extortion, and so on accordingly, a solitary disappointment can cause the disturbance of the entirety supply chain. For specific items, for example, natural, fit, veggie lover or reasonable exchange items, it is much harder for purchasers to know the items and data credibility. Indeed, even laws and authority confirmations have been useful, profound concerning furthermore, absence of trust of food industry and food quality actually remind. Many papers have been written on supply chain management but only papers have been published on food supply chain management [15], [17].

All the above discussion shows that many efforts have been carried out to overcome the problem of food security issues in the management of food chain. In this paper, we focused on the barriers and problems still faced by people in this chain after implementing blockchain with IoT. The novelty of this paper is apart from discussing the blockchain in food supply chain, we described the issues of food security with both these technologies and all the challenges in this chain described with detail.

## 3. RESEARCH METHODOLOGY

This research is based on literature review of food supply chain management and conducted on the research questions. There are so many papers on food supply chain management problems and the introduction of blockchain technology in food safety. There are so many challenges faced by blockchain in food supply chain management [19]. This Figure 1 shows the process of gathering data for this paper.
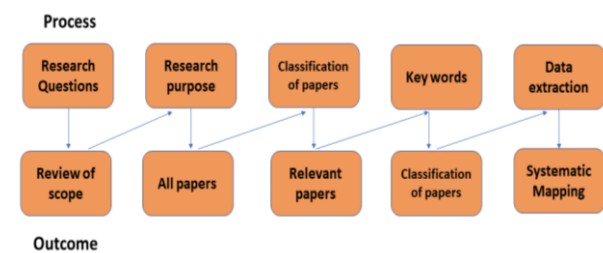


**Figure 1** Process of Research Strategy.

### *3.1. Research Objectives (RO)*

Many researches have been carried out regarding the issue of food safety in food supply chain management. This paper is to describe these challenges by summarizing many papers and collecting data about food supply chain management [5]. List of the main objectives of this research summarized below:

RQ1.The main objective of this paper is only focused on Food supply chain not included any paper which is on Supply chain management.

RQ2. Blockchain united with IoT in the management of food supply.

RQ3. Few issues and challenges still exist in food supply chain in implementing blockchain.
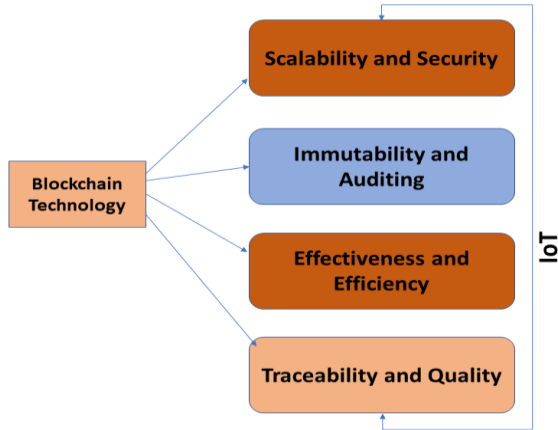


**Figure 2** Blockchain Technology with IoT.

This Figure 2 shows the interaction of IoT with blockchain technology to make food chain more secure and valuable for consumers.

### 3.2. Research Questions (RQ)

All these questions carried out according to literature review. By studying large number of papers to answer these research questions. These questions have been answered by available data on different research platforms. Find all these answers by different research papers which have provided very useful data according to this study of food supply chain management. Table 1 has been provided with these question answers of this research paper.

### 3.3. Search Scheme

The main purpose of Systematic Literature Review (SLR) paper is to gather data from different sources and give own review on these researches. This SLR has been written on Blockchain based food supply chain as given in Figure 2.

Different research papers selected for this literature review from following research resources. This Figure 3 shows the search string on this basis all the data of this paper has been gathered from IEEE digital library, Science direct, Google scholar's conference papers are included in this literature review. Primary, Secondary and tertiary keywords have been shown in Figure 2.

**Table 1.** Relevant Obtained Research Questions.

| | Research Question | Answers |
|---|---|---|
| **RQ1** | What are the use cases addressed by blockchain in the management of food supply chain? | Food traceability has been a top use case of food supply chain. |
| **RQ2** | What are the positive aspects of blockchain in food management supply chain? | Blockchain technology makes food supply chain more flexible than before. |
| **RQ3** | What are the major challenges of blockchain in food supply chain management? | Health problems faced by many people are the main challenge of blockchain in food supply chain. |
| **RQ4** | How blockchain can positively integrate with the IoT management in a food supply chain? | Blockchain paired with IoT and work best to solve complex problems in accounts of food supply chain to avoid any financial problem. |
| **RQ5** | How lack of understanding of blockchain affect the food supply chain management? | Many firms avoid to apply blockchain technology in their management system due to the lack of their staff training of this new technology. |
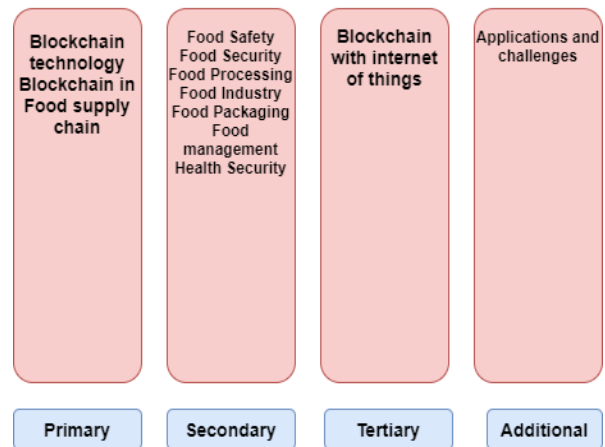


**Figure 3** Shows Search String.

All the papers were gathered through the following sources, IEEE digital library, Google scholar's, Science direct conference paper's literature and other needed data were added through the following search string, ''Food Supply chain'' AND (''Food Chain with Blockchain'' OR ''Food Safety with Blockchain'' OR ''Packaging'' OR ''Health'' OR ''Storage'' OR ''Processing'') AND (''Internet of things'' OR ''IoT Food security'' OR ''management'' OR ''Supply chain'' OR ''food

industry'' OR ''challenges'' OR ''benefits'' OR ''applications''). This fig.3 shows the gathering of data through step-by-step process [7].

### 3.4. Inclusion and Exclusion Criteria

**Table 2.** Inclusion and Exclusion Criteria.

| Inclusion | Exclusion |
|---|---|
| Papers published since 2015 to present | Papers before 2015 |
| Focused on food supply chain only | Focused on supply chain management |
| Literature review | Articles |
| Focused on blockchain technology | Other technologies than blockchain |
| Management only | Technical part |

Parameters defined for inclusion and exclusion criteria (IC) are shown in Table 2.

This Table 1 show all the papers selected for this literature review and also which data excluded for writing this paper. Table 2 shows the scoring criteria of this research paper.

**Table 3.** Scoring Criteria.

| Criterion | Rank | Score |
|---|---|---|
| 1. The purpose of study clearly described | Yes | 1 |
| | Partially | 0.5 |
| | No | 0 |
| 2.The challenges and issues in this paper explained | Yes | 1 |
| | Partially | 0.5 |
| | No | 0 |
| 3.Answers explained according to the literature review | Yes | 1 |
| | Partially | 0.5 |
| | No | 0 |
| 4. Data collection Well explained | Yes | 1 |
| | Partially | 0.5 |
| | No | 0 |
| 5. Conclusion relevant and future study discussed | Yes | 1 |
| | Partially | 0.5 |
| | No | 0 |

## 4. DATA ANALYSIS

In this part of paper all the results have been discussed on research of food supply chain management gathered by all the questions designed according to this paper and all discussed one by one and explained with detail.

### 4.1. Search Scheme

Food chain has been discussed in this paper with blockchain technology, as we know traceability has numerous definitions up until this point, the soonest definition was by International "The capacity to trace the set of experiences, application or area of an element by methods for recorded IDs" [12], [1]. Even more precisely, Food traceability is a fundamental for coordination the heads that catch, store, and send adequate information about a food, feed, food-conveying is correct animal or substance at all stages in the food inventory network so the thing can be checked for prosperity and quality control, followed upward, and followed drop at whatever point required. From the definition, record-keeping is a significant component for building great traceability [22], [10]. It not just permits organizations to have a perspective on the food supply chain, settle on good choices and find possible quality dangers by giving exact records; yet in addition gives the capacity of following in reverse and following forward along the supply chain during food review, which can improve the speed of detach and finding certain items from specific providers. For manageability reason, traceability is additionally an approach to screen environmental effects, hence, urge organizations to be more practical [12], [13]. By showing the assets and items stream, customers have better information and trust on the purchasing items. Traceability can be the additional incentive to the food items, and be utilized as an advertising device to draw in more customers and improve client trusts. The record keeping can be utilized as an essential device to urge providers to give quality items [19].
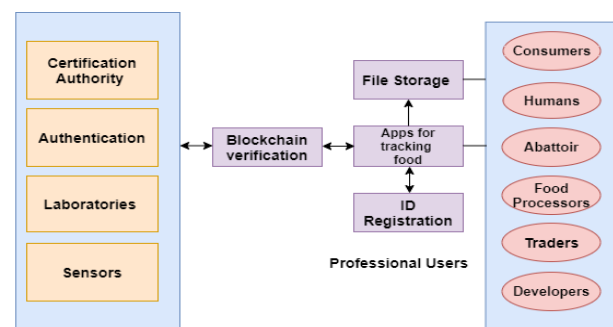


**Figure 4** Food Storage.

In Figure 4 food storage has been shown with the help of diagram. In this diagram food authentication have been provided through steps from registration to usage. In food supply chain, all the data collected and stored in blockchain. Sellers's consumers and stakeholders can only fetch this information of food if they are allowed. Food tested and verified by selling companies give proofs to their consumers to gain their trust and satisfied them by giving surety about what they are going to consume [26]. Each and every node contains data regarding food

chain which ensures the safety and quality of food because this data is verified and non-reversible [10]. By following the food distribution if any problem has been seen then just check the blockchain and trace where this problem came and replace this data node and change the food item which created this issue with accurate one. Through this mechanism it became very easy otherwise each and every package will be unpacked to find the problem [18]. Few organizations invest more to improve the quality of food and take extra precautionary measures to maintain their food quality. In this case, blockchain is the only solution which decrease the time of producers to produce good quality food by finding and tracing any defect so easily [6]. This creates trust between consumers and producers. Peer to peer ledger property of blockchain prevents the fear of indulgent of any fraud. Information about any product can be tracked and traced by any member at mean time [27]. All information about delivery of food can be checked by other members and can picked it up without any delay [13], [14]. Supervisors are the owner of this chain they have all the rights to share their private network with others according to their own trust level. So, few number or limited number of persons involved in this network it will allow access to database of the chain to only trusted members which can ensure the quality of food. In these days when everyone is facing health problems and feared more about any minor disease due to COVID-19, food safety becomes very important factor in our lives [26].
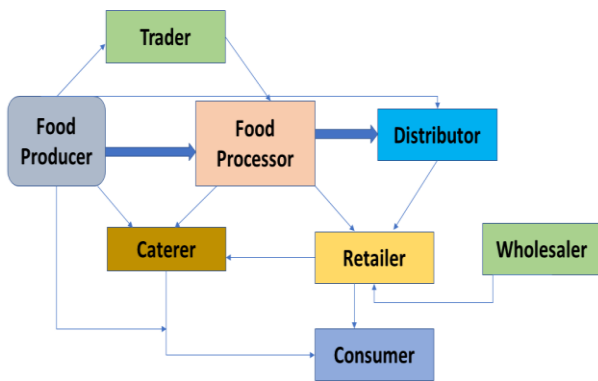


**Figure 5** Traditional Food supply chain network.

This Figure 5 shows the traditional supply of food. All stages of food supply have been included in this figure for understanding each stage of food supply.

### 4.2. Assessment and Discussion of Research Questions

This part of the paper consists of all the answers of research questions created by collecting different data on Food Supply Chain Management.

### 4.2.1. What are the use cases addressed by blockchain in food supply chain management?

Many studies have been provided with detail to address many complex problems solved by blockchain in food supply. The subsequent test is known as the "scalability trilemma" by the organizer of the smart contract stage Ethereum. It is difficult to accomplish decentralization, adaptability and security simultaneously, just two out of three can be accomplished at one at once [4]. Scalability decides how huge the limit the organization can be. Presently, Ethereum can deal with 15 exchanges each second, while other stage, for example, Visa can handle 45,000 exchanges each second [10]. Mining interaction can guarantee serious level of decentralization and security; it can also cause moderate speed of approvals when an enormous number of exchanges are occurring. For tremendous worldwide food supply chain, the scale can reach about Petabyte each year by suspicion [20]. In 2019, Pearson accepted that blockchain is more liable to occur in specialty zones in a food supply chain, where the blockchain possibilities are fundamentally required. Various phases of the food supply chain may have extraordinary prerequisites for blockchain selection [19].

### 4.2.2. What are the positive aspects of blockchain in food supply chain management?

In the centralized supply chain, big organizations will in general pick chosen data to open up to people in general, which can cause the absence of transparency and trust issues inside a supply chain, particularly for specific items, for example, Halal, natural, and so forth Organizations themselves, even specialists can add to cover up unlawful perils [27], [30]. For instance, the China Sanlu milk embarrassment didn't get uncovered on the primary spot because of the concealment by organization chiefs and other specialists [10]. Data validity is addressed in concentrated food supply chain. Blockchain, as a decentralized stage, permits approved clients have equivalent forces to have a duplicate of history and access it straightforwardly without focal force intercession, which can remove any enormous controls over the data stream and give transparency along the supply chain, might be the answer for data disparity [31].

### 4.2.3. What Are The Major Challenges Of Blockchain In Food Supply Chain Management?

Information fraud is a major issue to worry about inside the food supply chain, where transparency and deceivability stay low. Organizations can delete or change history to get away from taking obligations or concealing reality. By blockchain, whenever exchanges are approved and are added on the blockchain, the first records stay perpetual and can be recovered [7]. In 2016, the meat of pork is founded in the meal prepared for new born. It was a major food insecurity created at that time. The discovering shows that blockchain can improve information realness, diminish information blunders and

gain trust. The digitalization of records and archives not exclusively can save time from manual paper check, yet additionally wipe out dangers from information fraud [23].

### 4.2.4. What Are The Benefits Of Using Blockchain To Overcome The Complexity In Management Of Food Supply Chain?

Many complexities in food chain are resolved by blockchain. Major is that it removes the third person in this chain. Food delivery is ensured by two parties only [18]. No one can interfere without the permission or concern of these two parties and no change can be made by any person from outsource. If there is any problem in food product then you can easily trace who cause this problem [19]. You do not need to check manually that who made any change so you will find the cause of this problem. Encrypted codes are used on the packing of products which can be decrypted by the one who is allowed.

### 4.2.5. How Lack Of Understanding Of Blockchain Affect The Food Supply Chain Management?

Public actually has insufficient information on blockchain, even numerous individuals working inside the SCM territory actually experiencing difficulties to completely comprehend possibilities [1]. Researchers proposed numerous organizations would in general pick blockchain as an answer prior to diagnosing organization issues, which show an absence of profound comprehension of blockchain genuine possibilities [18]. More trainers and experts in this work should be hired by companies to train their employees about blockchain. It will be helpful in inquiring food and fast delivery and manufacture [16], [5].

## 5. ISSUES AND CHALLENGES

In these days everyone one is accepting the success of blockchain in every field and consider it trustable technology. Blockchain is an amazing asset to make food secure from frauds and helps in tracing the defects caused by anyone and also saves money by not tracking each and every one who delivers products in supply chain management [6]. Few features of blockchain technology gives us frameworks for traceability of food supply chain. By using this technology, humans are getting so much benefit by saving their time to sit and examine food just like the example of mangoes growth for which everyone sit tightly and note the cycle of the development of mango to record the development cycle for seven days and every one participating in this experiment spent so much time which is now decreased to few seconds rather than days [5]. Blockchain innovation can guarantee the realness of the recorded information. In any case, it

requires some serious energy from information age to blockchain input, human blunder can influence the valid ness of the info data. Hence, how to guarantee the credibility of the data in this interaction is a significant test [16], [20].
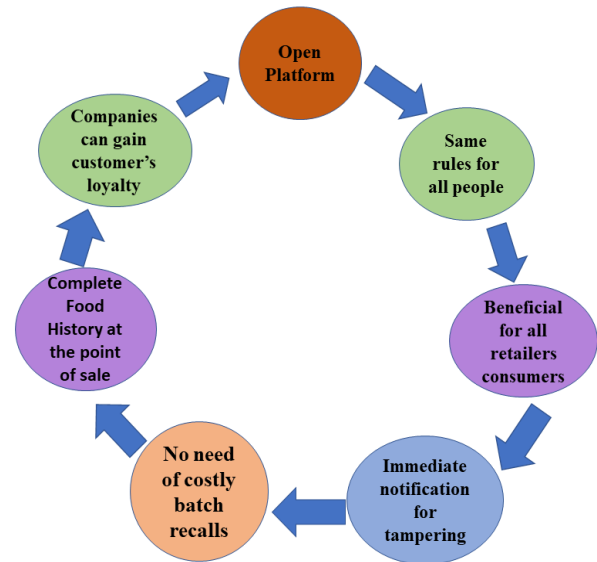


**Figure 6** Food Supply Chain benefits with Blockchain.

This Figure 6 shows the cycle of food supply chain's benefits with blockchain technology.

### 5.1. Packaging and Storing

Food items needs to be packed with cleanliness and in clean environments according to food science measures [3]. Many labs tested food poisoning issue; result declared are due to packaging of food in plastic bags at inaccurate temperature. Delivering large amount of food also takes more place for storage which is very difficult and data that created to record this huge amount also cause problems. IoT helps in saving records large amount of data step by step in blockchain [26].

### 5.2. Food Safety

In food supply chain, all the data collected and stored in blockchain. Sellers's consumers and stakeholders can only fetch this information of food if they are allowed [2]. Food tested and verified by selling companies give proofs to their consumers to gain their trust and satisfied them by giving surety about what they are going to consume. Each and every node contains data regarding food chain which ensures the safety and quality of food because this data is verified and non-reversible [11], [15]. By following the food distribution if any problem has been seen then just check the blockchain and trace where this problem came and replace this data node and change the food item which created this issue with accurate one [12]. Through this mechanism it became very easy otherwise each and every package will be unpacked to find the

problem. Few organizations invest more to improve the quality of food and take extra precautionary measures to maintain their food quality. In this case, blockchain is the only solution which decrease the time of producers to produce good quality food by finding and tracing any defect so easily. This creates trust between consumers and producers [19]. Peer to peer ledger property of blockchain prevents the fear of indulgent of any fraud. Information about any product can be tracked and traced by any member at mean time [27]. All information about delivery of food can be checked by other members and can picked it up without any delay. Supervisors are the owner of this chain they have all the rights to share their private network with others according to their own trust level [26]. So, few number or limited number of persons involved in this network it will allow access to database of the chain to only trusted members which can ensure the quality of food. In these days when everyone is facing health problems and feared more about any minor disease due to COVID-19, food safety becomes very important factor in our lives [22].

### 5.3. Authenticity

Consensus algorithm helps in data security authentication. Clients can be able to make digital calculations. When third party removed by the system then the chances of hacking will also be reduced.
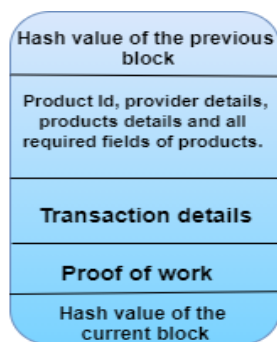


**Figure 7** Structure of Food Chain.

For example, if few organizations have competition between them and one of they tried to affect the reputation of the other. It can be possible that it tries to hack data of this organization and make changes in it accordingly. So, without getting trapped into it make your food chain secure [10]. Do not allow anyone to make any change and if someone does that it will be very easy to trace by the main feature of blockchain that is transparency. Data will be saved and no one can remove data at any cost [23]. This Figure 7 shows the contents in the hash. Hash shows the flow of products in FSC and contains all the data of transaction and details of products.

**Table 4.** Pros and Cons.

| Blockchain/IoT Pros | Blockchain/IoT Cons |
|---|---|
| Relative analysis between unified traceability framework and blockchain based traceability framework the blockchain based traceability framework is productive. Generally, the blockchain is utilized in the fields where there is a trust issue like store network. Presently this framework has prepared for the straightforward store network. | When blockchain integrated with IoT cost of RIFD (radio frequency identification) costs very high as compared to the other tags like barcode and QR tracking systems. |
| Manual work is reduced as all the work is move to automatized mode. | Blockchain technology itself is very difficult for us as many of us are unaware of it, so when it is integrated with IoT then it will become more complex for normal people. |
| As the tracking details mentioned on the product easily recognize the date of expiry and make it easy to know about the delivery of the product from retailer. | Many firms due to the costly method cannot be able to implement this technology to their system. |
| Since RFID tags are utilized the data is encrypted and every item has its own ID of RFID tags. This makes the data safe and no one can get to the data. | |
| The outsider contribution is maintained a strategic distance from in each framework there will be a third everyday person who will go about as power along these lines, the framework is likewise centralized.in this blockchain technology all are similarly treated so authorizing act is carefully is impossible here. | . |

## 5.4. Pros and Cons of Blockchain with and without IoT



**Figure 8** Advantages of Blockchain with IoT.

This Figure 8 shows benefits of blockchain in food supply chain. This table describes the advantages and disadvantages of blockchain with and without IoT [23], [25]. Table VI. Shows pros and cons of Food supply chain with Blockchain with IoT or without IoT.

## 6. CONCLUSION

Usage of blockchain, food supply chain industry has acquired various advantages to develop and move towards decentralization and accomplish a trust less climate for all areas of life. In any case, nevertheless the trust less idea of blockchain, it is difficult to completely keep up trust between the vender and purchaser of the item. This is on the grounds that the substances may act malignantly and the purchaser can question their validity. Additionally, supply chain includes different cycles and sub-measures that should be done in a decentralized way to accomplish traceability, responsibility and security. The paper gives a crucial and complete comprehension of blockchain and its possible effects, which won't just can be a valuable control for new specialist in important field, yet in addition can give some profound bits of knowledge to specialists, for example, organization leaders. By distinguishing and examining the most related research work and papers, this study describes a strong platform for future exploration on this technology, and focuses exploration bearings. This Paper additionally gives innovators a superior comprehension of blockchain, and clarifies them some conceivable appropriation challenges and reminds them to utilize this latest technology to resolve these issues. In this case, the future research focuses on blockchain usage in reality and give more experimental proof. Furthermore, food supply chain is muddled and different. This paper provides issues in food supply chain management that how they can improve the quality of food by applying new technologies.

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