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# Applications of Internet of Things in the Food Supply Chain: a Literature Review

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## Abstract

This paper examines the use of the Internet of Things (IoT) in the Food Supply Chain (FSC) and identifies the strengths and weaknesses of this system. Since this paper is a review study, the papers published from 2014 to June 2021 have been studied and 93 articles related to the field of IoT applications in the FSC have been reviewed. By reviewing the literature, six basic applications obtained for this type of network include transportation procurement, food production, resource/waste management, food safety improvement, food quality maintenance, and FSC transparency. Clustering is used to achieve these. Cluster analysis suggests that researchers should pay more attention to IoT applications for product quality and transparency throughout the supply chain, and consider IT-based systems seamlessly at each level of the supply chain.

**Keywords:** Internet of things, food supply chain, IoT-based supply chain processes, virtualization.

## 1 | Introduction



Changes in the competitive market environment and the shift of companies to offer products globally have led organizations to optimize their company's supply chain to survive in the market and gain more share of product sales in global markets to be able to quickly respond to the needs of consumers in the shortest time, which have the lowest cost and highest quality [1]. Therefore, all levels of the supply chain from raw material suppliers to product distribution and then to customers must be carefully monitored, planned, and controlled. Supply Chain Management (SCM) can be defined as a process consisting of planning, execution, and control of all operations related to supply, production, warehousing, and distribution of products to customers [2]. In a simpler term, SCM focuses on the integration of activities and flows of financial information and materials between levels of the chain to achieve a sustainable competitive advantage [3]. Today, many supply chains have spread to large parts of the world and are exposed to very high global risks [4].

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So, new customers today want different products or different price levels and different types of customizations. The complexity of products is increasing so rapidly, which has led to rapid changes in technology [5]. Different economic, political, social, environmental, and natural factors affect the demand of customers for different products at different times and places. Therefore, organizations in such a complex competitive environment must have high flexibility and be very agile to be able to estimate a wide range of customer needs and wants in the shortest possible time. To balance the supply chain level, the entire supply chain from the supplier level to the distributor level must be flexible and have the necessary speed to meet customer needs. Information technology is one of the important factors in SCM in complex competitive conditions for the organization and helps each supply chain in the direction of agility and rapid flexibility [6].

Information Technology (IT) has led to customers quickly address their needs and the organization is faster than managing its supply chain levels to meet customer needs. One of the most important and latest developments in the field of IT is the Internet of Things (IoT). The IoT in the supply chain can take supply chain communication to a higher level and improve human-to-human interaction and object coordination [7]. This new technology by collecting and analyzing data can quickly increase supply chain agility and make quick decisions at any level of the supply chain from a supplier to a distributor. Since in the traditional supply chain, collecting and analyzing big data is not an easy task, IoT can perform the ability to collect, analyze, and provide appropriate solutions in the shortest possible time. In this paper, a review study is conducted by studying the existing literature on IoT and its application in the Food Supply Chain (FSC). Therefore, by reviewing articles, books, and documents published from 2010 to 2021, the IoT in the field of the FSC has been studied and its impact on various food supply, production, and distribution companies has been analyzed. In the following, definitions of the FSC, IoT, and its application in different parts of the FSC are presented. Then, the collected information from the study of the literature is examined to show the place of the IoT in the FSC and to determine the research gaps in the future.

The structure of the paper is as follows. In Section 2, definitions of the IoT, FSC, and IoT applications in the FSC are discussed. In Section 3, the method of the classification and analysis of the literature of the studied subject is presented. In Section 4, using different tools and diagrams, different types of IoT applications in the FSC, and finally, the gaps created in the studies are examined. Section 5 concludes and presents future studies for the implementation of the IoT in the FSC.

## 2 | Literature Review of IoT Applications in the Food Supply Chain

The Food Supply Chain (FSC) is under tremendous pressure to improve not only revenue but also its overall sustainability and supply chain efficiency [8]. Also, if you need to invest to improve performance and sustainability, the goal of the FSC is to keep costs down, which is a difficult task. However, the advent of digitalization and related technologies is helping businesses cope with this difficult task. In particular, FSCs have witnessed a combination of information technology and operations, thanks to developments and synergies between the respective regions that have led to the IoT. The IoT term was coined in 1999 by the MIT Auto-ID Lab with special reference to Kevin Ashton [9]. The IoT-GSI has defined the IoT as a "global infrastructure for the information society that enables advanced services through the connection of physical and virtual objects based on existing and evolving information and communication technologies" [10]. Jagtap et al. [11] described the IoT as a complex physical cyber system, which includes a variety of devices and systems for measuring, identifying, communicating, networking, and informatics, and seamlessly based on people and objects. It connects interests so that anyone can access the information of any object and service more efficiently through devices and media anytime and anywhere.

Therefore, the concept of the IoT can be considered as providing a solution that collects and integrates a huge amount of data generated from supply chains. Applications built on IoT operating systems enable faster, better data collection, analysis, and decision-making to increase operational efficiency. *Fig. 1*

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shows a food factory using the IoT. This figure shows how the IoT can empower stakeholders and factory management through the ability to monitor food production flows in real time, which allows them to control and manage connected equipment. It also allows them to identify quality issues and address them promptly. They have more transparency and vision in inventory management and have the necessary flexibility to make forecasts. This figure also shows how managers, R&D professionals, and factory queue employees can reap the benefits of using the IoT [11].

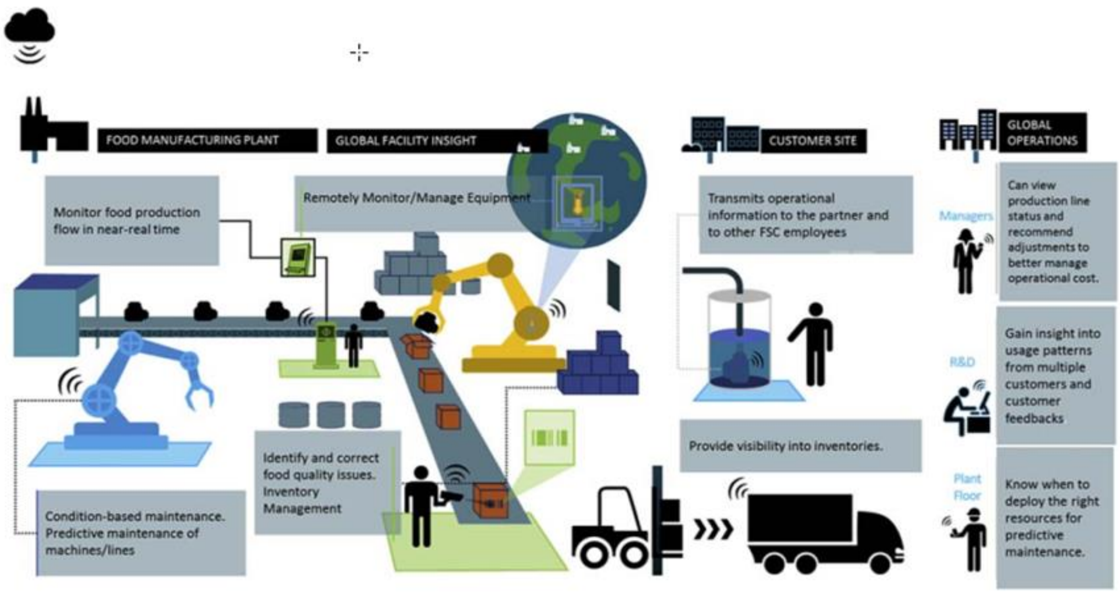


**Fig. 1. Application of the IoT in the food supply chain.**

## 2.1 | IoT Architecture in the Food Supply Chain

The IoT in the FSC is designed to easily connect machines, equipment, and other items over the network. Therefore, an IoT architecture is needed to collect data seamlessly and transfer it securely for further analysis [12]. The most basic IoT architecture consists of three network layers and application layers, which are described below [13], [14]:

**Observation layer:** a physical layer consisting of sensors and actuators to measure and collect data about physical parameters as well as identify other intelligent objects around.

**Network layer:** responsible for communicating with other intelligent objects, network devices, and servers, as well as its transmission and processing.

**Application layer:** this layer provides services to specific applications to users and simultaneously defines several applications for installing IoT (e.g., smart health, smart home, and smart city).

However, for FSCs, the most appropriate IoT architecture consists of four layers: measurement, network, service, and application. *Fig. 2* shows the IoT architecture in the FSC [11].

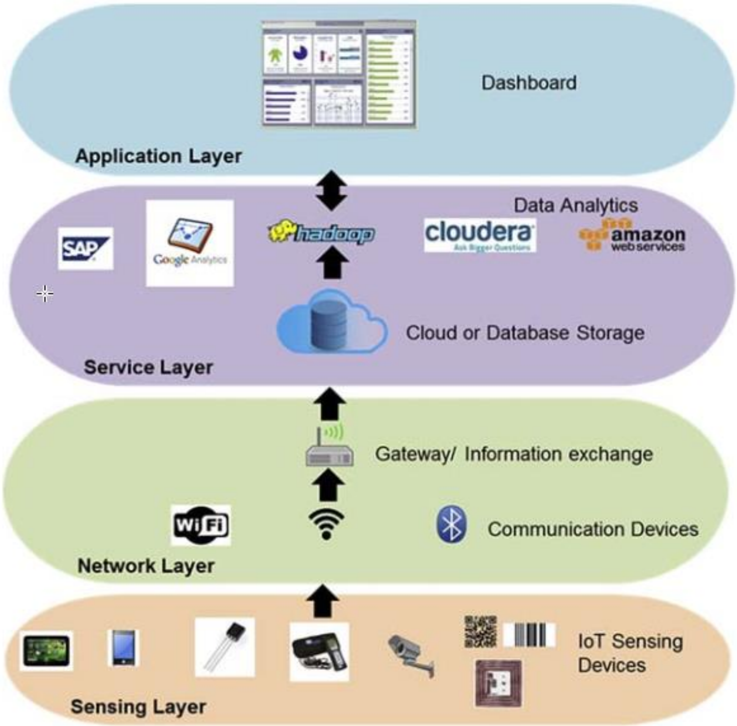


Fig. 2. IoT architecture in the food supply chain.

I. The measurement layer contains data such as time, temperature, location, machine, etc. In general, in the FSC, data are collected using sensors, Radio Frequency Identification (RFID), cameras, and so on. All data collected from the raw material source to the end of the product life is pre-processed in this layer.

II. The network layer transmits the data collected in the sensor layer to the service layer through various network technologies (e.g., Wireless Sensor Network (WSN), Bluetooth, and WiFi router).

III. The service layer includes a wide range of analytics engines and services in which data is analyzed or stored.

IV. The application layer consists of various programs and modules (e.g., tracking, production efficiency, and food quality), which can be done by supply chain actors to view the information in real time and make appropriate decisions.

## 2.2 | Applications of the IoT in the Food Supply Chain

Currently, many IoT applications depend on the type of industry that they use. They can be classified according to the type of network availability, coverage, scale, heterogeneity, repeatability, user engagement, and impact [15]. Unique FSCs have wide geographical coverage, complex operational processes with a large number of stakeholders throughout the chain, and provide insights into food quality, operational efficiency, and food safety [16], [17]. The availability of nutritious food is more important to everyone than any economic, social, or environmental development. The world's population is projected to reach nine billion by 2050, which will completely change the world and also put a lot of pressure on FSCs. However, the development of IoT technology is likely to provide encouraging solutions [18]. The IoT can play a role in the functioning of every part of the FSC, from farms to food production, processing, storage, distribution, and consumption. The IoT can address tracking, visibility, transparency, and controllability challenges. Safety, efficiency, transparency, and stability are some of the features required in the FSC.

## 2.3 | Applications of the IoT in Food Transportation Procurement

During the transportation of food, the product that is transported can face various challenges, such as temperature control, hygiene and pest control, traceability, product management (i.e., movement of

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goods, damage, rejection, and safety), preventive maintenance of the vehicle/container and staff management (i.e., handling, personal hygiene, safety, policies, and training). Using the IoT, it is possible to track all food-related activities. RFID technology is one of the most effective and inexpensive IoT tools in tracking food products. RFID tags can have specific and important information about the food products shipped and can easily communicate via a wireless network. In the event of a food recall or food safety, alerts are sent immediately throughout the supply chain and the damaged product is quarantined immediately. The low cost of the wireless remote system enables the ability to establish a wireless network in food transport vehicles and to monitor food safety during transport. For example, with the help of IoT systems integrated into risk analysis processes, Hazard Analysis Critical Control Points (HACCP), FSC actors can control temperature and other conditions in real time, effective cold chain management as well as compliance global and monitor and document. Food transport vehicles can use simple and complex wireless systems that allow continuous connection and continuous access to information in real time [19].

## 2.4 | Application of the IoT in Production and Improvement of Food Safety

Data collected from different plant units (e.g., machinery, staff, vehicles, and materials) can be used in procedures and processes for optimizing food production systems without human intervention. By supporting real-time information, algorithms, and actuators, the designed control software can make the best decision and reduce the stimuli from any deviation from the plot. Current FSCs are long and complex with increasing safety risks and constant pressure from consumers to provide high-quality and safe food products. All actors in FSCs contribute to food safety information, which can lead to unpredictable risks due to incorrect data sharing or delays. IoT development, while providing effective collection and sharing and the opportunity to analyze data, can identify any deficiencies and issue food safety warnings before production. Results in the development of a system that can predict potential food safety hazards and warn if the safety and quality of food produced are violated. Therefore, any player in the FSC can help reduce the deviation in quality and waste of resources and thus prevent any food safety-related incidents. Maintaining and preparing quality food with an advance warning about food safety is the most important aspect of achieving sustainability in the FSC. At present, much attention has been paid to the issue of food safety and much work has been done to address this challenge. One of these is the pre-warning system, which can identify and warn actors about food safety issues before they become a major crisis. The alert system is implemented in conjunction with HACCP-based tracking systems. Current FSCs are composed of several actors that make it difficult to regulate, track, monitor, and control the food trade. Hence, most food safety incidents occur with inadequate monitoring, so the need for a prior warning system to control the food trade in an efficient and fully automated manner is palpable.

## 2.5 | Use of the IoT in Improving the Quality and Transparency of the Food Supply Chain

Various image processing technologies and sensors can help maintain the quality and specifications of raw materials and final products [20]. Sensors can continuously monitor the quality of the product, and any deviation from the set standards can be immediately detected and corrected. Other benefits of these sensors include product tracking, employee tracking, and real-time production analysis for efficiency. This leads to the optimization of FSC activities. End consumers and buyers need transparency to have a complete view of how their food is prepared and processed. Full tracking and visibility throughout the supply chain help food producers grow their business by gaining customer trust and loyalty. Although current FSCs are often very long and complex, IoT technology can make tracking easy for all FSC actors. Also, transparency can be beneficial for food producers as it leads to better stock management, labor management, cost reduction, and shorter lead times. These benefits can be achieved by addressing supply chain inefficiencies, meeting and exceeding minimum food safety requirements, and providing a full view of customers. In the context of the FSC, transparency can be defined as the information available to all actors involved in a supply chain network. Transparency in the FSC can indicate the ability to trace the product from farm to fork, for example, where the raw material is prepared, how it is processed and delivered to consumers. Blockchain technology can provide greater transparency throughout the FSC [21].

## 3 | Research method

In this section, the research method is presented to review the literature studied in the field of IoT applications in the FSC. Therefore, first, a summary of descriptive statistics is presented. Then, by using cluster analysis, articles in different clusters are categorized and analyzed. In other words, the main purpose of this article is to provide a roadmap for reviewing the current situation and evaluating the use of the IoT in the FSC, and identifying existing capacities for future research. To do this, first review all published articles on the use of the IoT in the FSC in various databases of some publishers, such as Elsevier (www.sciencedirect.com), Springer (www.springerlink.com), Taylor and Francis (www.tandf.co.uk), Emerald (www.emeraldinsight) and the size of papers published in international conferences from 2014 to June 2021. About this issue, 93 articles that have a direct relationship with the food safety chain and the use of the IoT have carefully been studied and reviewed. To review these articles, the clustering method is used and articles are classified into six categories including transportation procurement, food production, resource/waste management, food safety improvement, food quality maintenance, and transparency in the FSC. The impact of each IoT application on each cluster is also investigated.

## 4 | Research Findings

In this section, the current status of documents and articles published in the field of IoT applications in the food safety chain and their classification in different sections are discussed. From now on, descriptive statistics (e.g., the numbers of articles published in different years and journals) are presented. Then, by using the *K*-means clustering method, descriptive statistics of each of the clusters are addressed.

### 4.1 | Descriptive Statistics of Published Papers

According to a search of various publishers' databases from 2014 to June 2021, 93 articles, books, and other documents were found. *Fig. 3* shows the number of publications in different years. Due to this issue, most of the articles (i.e., 21) were published in 2020.

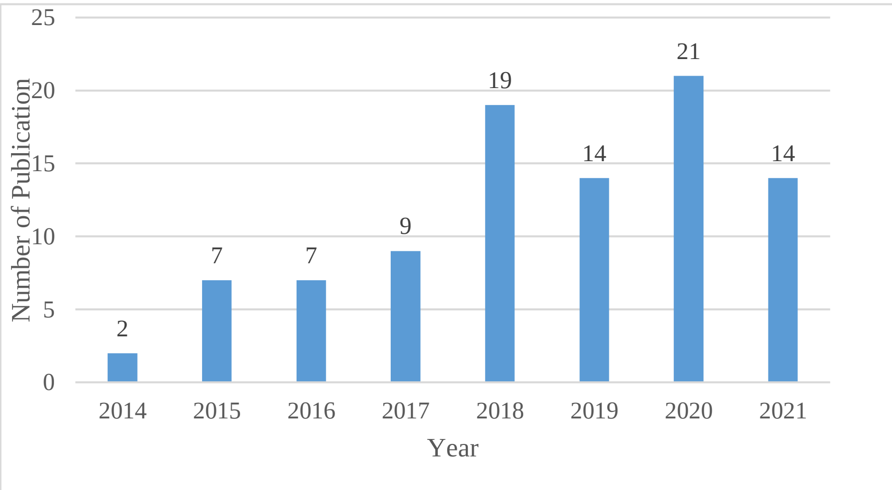


**Fig. 3. Number of articles published between 2014 and 2020.**

*Table 1* shows the number of papers published in the index of different journals. Therefore, the classification in this section is based on the number of articles published in journals with the Journal Citation Report (JCR) index, journals with the Master Journal List index, journals with the Scopus index, and journals with other indices.

*Table 2* classifies the literature studied in the field of publication type. According to this table, 74 items of the literature were studied including journal articles, 15 items including articles published in international conferences, and four items in the form of book collections. Also, this table shows the number of articles and books published by publishers. Based on this and by the research method, the classification of articles was based on the publishers Elsevier, Springer, TanfF, Emerald, IEEExplore, and other publishers. *Fig. 4* shows the number of IoT publications in the FSC by different publishers.

**Table 1. Number of papers published in journals with different indices.**

| # | JCR | | | Master Journal List | Scopus | | | | Other |
|---|---|---|---|---|---|---|---|---|---|
| Q. | Q1 | Q2 | Q3 | | Q1 | Q2 | Q3 | Q4 | |
| No. | 30 | 14 | 1 | 45 | 32 | 13 | 2 | 2 | 39 |

**Table 2. Number of journal articles, conferences, and books published in journals with different indexes**

| Type of publications | Number |
|---|---|
| Journal | 74 |
| Conference | 15 |
| Book (series/chapter) | 4 |

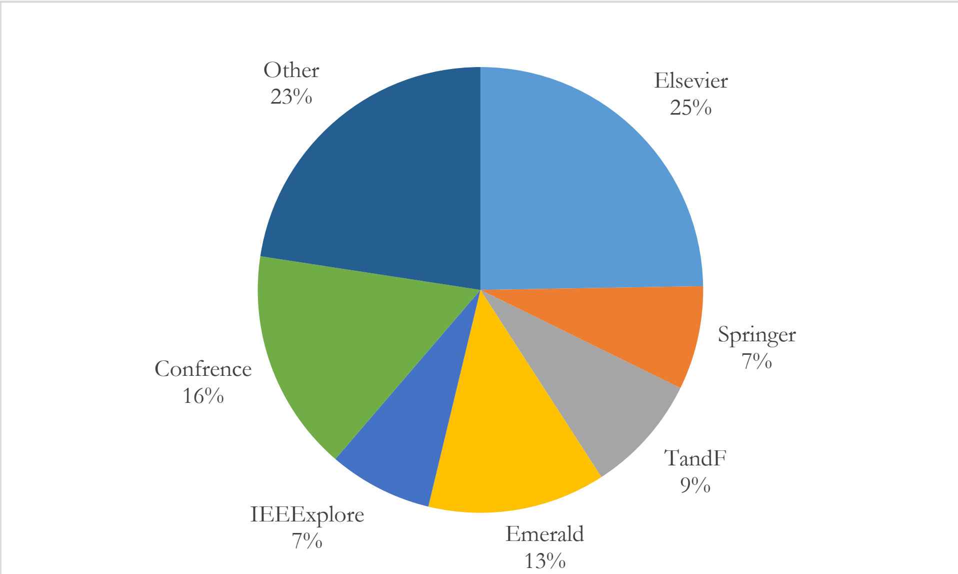


**Fig. 4. Number of articles published by different publishers.**

According to the summary of the statistics provided, it can be seen that most of the articles published in reputable journals had an impact factor of Q1, with the highest number of citations to 806 articles. Elsevier publishes the most IoT articles in the FSC, with topics such as food control, simulation, blockchain, and food transportation. By studying the articles, it is observed that less than 12% of the articles have been done on mathematical modeling, optimization, and simulation of IoT in the FSC, and in the rest of them, operational strategies and IoT impact have been presented.

## 4.2 | Literature Review

In this section, clustering and analysis of published articles in various fields of IoT applications in the FSC are discussed. According to *Fig. 5*, six different clusters for IoT applications in the FSC are listed according to the published years. The first cluster includes "Transportation Supplies in the FSC"; the second cluster includes "Food Production"; the third cluster includes "Resource/Waste Management"; the fourth cluster includes "Improving Food Safety"; the fifth cluster includes "Maintaining Food Quality" and the sixth cluster includes "Food Supply Chain Transparency".

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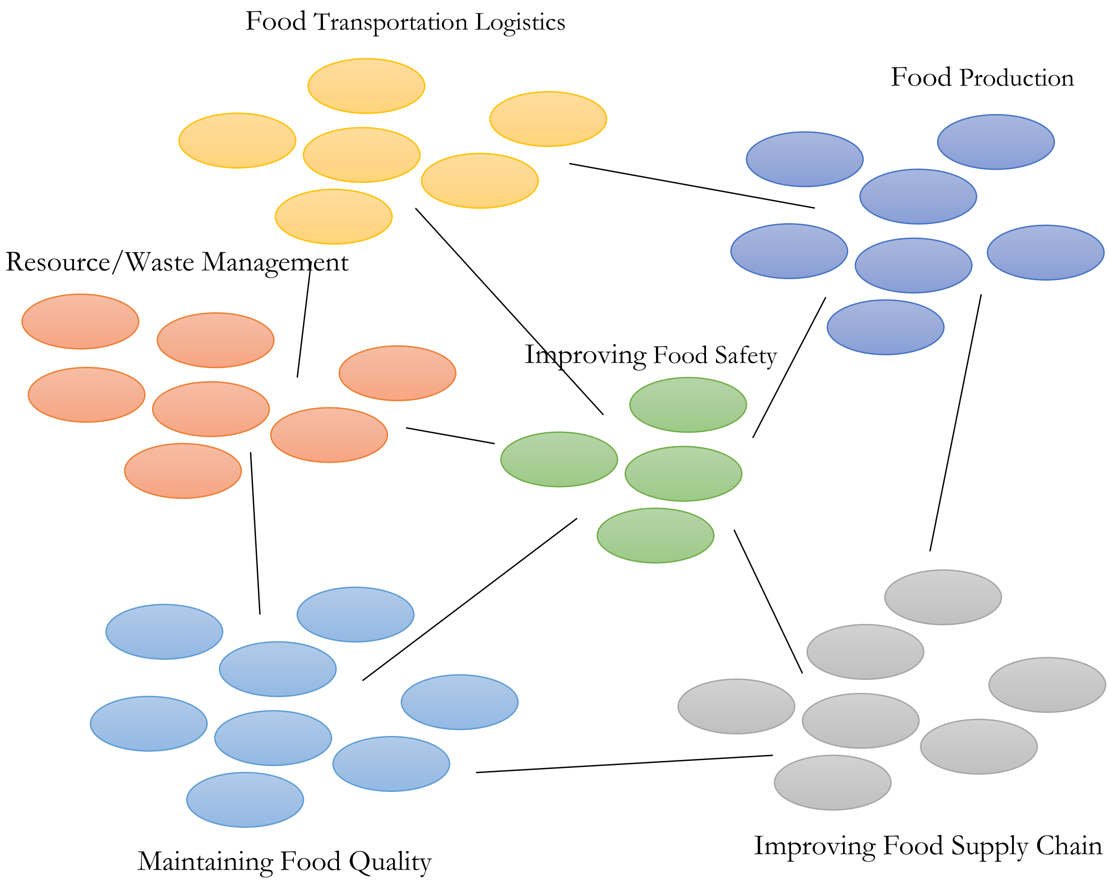


**Fig. 5. Clustering of IoT applications in the food supply chain.**

According to the clustering, *Table 3* shows the number of publications published in each cluster by year of publication.

**Table 3. Number of the journal, conference, and published articles related to IoT applications.**

| Year | Food Transportation Logistics | Food Production | Resource/Waste Management | Improving Food Safety | Maintaining Food Quality | Improving FSC Transparency |
|---|---|---|---|---|---|---|
| 2014 | 0 | 1 | 0 | 0 | 1 | 0 |
| 2015 | 0 | 1 | 2 | 0 | 2 | 1 |
| 2016 | 1 | 1 | 1 | 0 | 2 | 2 |
| 2017 | 2 | 0 | 5 | 0 | 2 | 2 |
| 2018 | 1 | 3 | 2 | 5 | 4 | 1 |
| 2019 | 3 | 2 | 1 | 2 | 2 | 4 |
| 2020 | 3 | 5 | 5 | 2 | 5 | 1 |
| 2021 | 3 | 4 | 2 | 1 | 1 | 2 |

According to the analysis, the focus of articles in recent years has been on food quality, reducing food waste, and food production. Few articles have also discussed food safety and supply chain transparency. By focusing on each of the IoT applications in the FSC, the role of the supply chain in each process can be examined. In the use of the IoT in the field of food transportation procurement, we can name roles (e.g., capacity, planning, optimization, energy management, and error detection). In the use of the IoT in the food production sector, we can mention roles (e.g., raw material supply, material composition, after-sales service, and food storage). Three key roles for resource/waste management in the FSC are identified, including reducing food waste, reducing energy, and water consumption. In the following, the role of IoT applications processes in the FSC is examined.

#### 4.2.1 | Procurement of food transportation

Ferreira et al. [19] discussed the use of several vehicle measurement applications and network range connections on vehicle nodes. Also, Chen et al. [22] proposed the concept of the IoT to increase transportation safety and network security by extracting effective information from the physical and network data space. The MovingNet e a Vehicle Ad-Hoc network is a sensor consisting of several sensors on a public transportation system to detect the production of counterfeit alcohol [23]. To improve transportation efficiency, Zhang et al. [24] proposed IoT technologies in the food supply chain, including the design of an IoT-based intelligent monitoring system (e.g., RFID, sensors, and wireless communication technology) to monitor the temperature and humidity inside a refrigerated truck, and detect and track loads in real time. Ma et al. [25] examined the integration of the IoT into the Enterprise Resource Planning (ERP) system, a pork supply chain, to establish a rapid alert system to know pork quality, reduce procurement costs, and improve circulation efficiency. Lacey et al. [26] categorized IoT applications in transportation by supply and demand. *Table 4* shows the extensive literature review of the use of the IoT in food transportation procurement in the FSC.

**Table 4. Application of the IoT in food transportation procurement in the food supply chain.**

| Process | Role of the IoT | Impact | References |
|---|---|---|---|
| Food transportation logistics | Capacity sensing | Systems that can detect and communicate open spaces in a warehouse, port, or parking lot | [27]-[29] |
| | Planning and reporting | Systems that can detect and analyze events, such as traffic accidents within a delivery network, allowing for more accurate delivery dates | [22], [30], [31] |
| | Route optimization | Tools that can map the shortest or most fuel-efficient route, (e.g., delivery vehicles) | [32], [33] |
| | Energy management | Tools that monitor and enable decision making about the use of fuel, lighting, and heating/cooling within vehicle fleets and facilities | [34], [35] |
| | Fault detection and resolution | Systems that can monitor fleets of vehicles, aircraft, or ships for faults and maintenance needs, improving uptime for the fleet | [36], [37] |

#### 4.2.2 | Food production

Aung et al. [38] examined the importance of the use of the IoT in providing the raw materials needed to produce quality food through the selection of suppliers. Garcia-Garcia et al. [39] proposed monitoring the efficiency of raw materials in a food factory, IoT technologies in the food supply chain to manage it, and providing a systematic approach to identifying the most sustainable solution for managing it. Ekren et al. [40] provided a net-based system to provide after-sales service for manufactured food products. They sought to improve the food quality of products by gathering macro information from customers. *Table (5)* shows the extensive literature review of the use of the IoT in food production in the FSC.

**Table 5. Applications of the IoT in food production in the food supply chain.**

| Process | Role of the IoT | Impact | References |
|---|---|---|---|
| Food production | Supply of raw materials | Systems that can be used to automate work procedures and processes to optimize food production systems without human interference | [38], [41]-[43] |
| | After-sales service | | [44]-[47] |
| | Maintenance | | [48]-[52] |
| | Combine product | | [53]-[56] |

### 4.2.3 | Resource/waste management

The use of internal and external sensors and simulation systems can provide complete energy monitoring in production systems by ISO 14955 and ISO 50001 [57]. Henningsson et al. [58] demonstrated the value of resource efficiency in the food industry and the importance of reducing electricity and water consumption as well as improving effluent quality, which can lead to significant savings. Therefore, by improving the relationship between all levels (i.e., producer, producer, retailer, and consumer) in the FSC and using technology to reduce labor costs, materials and facilities, can be a production and consumption system achieved more stable. Garcia-Garcia et al. [59] discussed the amount of food waste in the FSCs of developing and developed countries. Sheppard et al. [60] proposed a knowledge-based management system to increase the effectiveness and efficiency of existing tools for the management and added value of food waste. Wang and Yue [61] provided a framework supported by the IoT to warn of food safety hazards and prevent food wastage in the FSC. Hong et al. [62] proposed an IoT-based waste management system for food waste to improve the efficiency and effectiveness of food waste management in Seoul. The proposed system not only wastes 33% of food but also saves 16% of energy. Jagtap et al. [63] showed an IoT-based digital food tracking system that reduces food waste in a ready-to-eat food factory by 60.7%. Jagtap et al. [64] demonstrated the importance of IoT technology, which leads to better energy monitoring and management with significant cost savings. With this technology, energy consumption with tighter controls is greatly reduced. Shrouf and Miragliotta [65] showed how management in a factory can easily approach the implementation of the IoT by collecting and analyzing energy consumption and thus improving the energy-conscious decision-making process. *Table 6* shows the extensive literature review of the use of the IoT in resource/waste management in the FSC.

**Table 6. Use of the IoT in resource management/waste in the food supply chain.**

| Process | Role of the IoT | Impact | References |
|---|---|---|---|
| Resource/waste management | Reducing food waste generation | Systems that can reduce waste generation, energy consumption, and water | [37], [66]-[70] |
| | Reducing energy consumption | | [11], [71]-[75] |
| | Reducing water consumption | | [76]-[81] |

### 4.2.4 | Improving food safety

Robles et al. [82] presented an intelligent model based on linking IoT technologies with operational processes and decision support systems. Melo et al. [83] proposed an automated IoT-based solution to minimize water wastage while improving food safety. Drenoyanis et al. [84] proposed a new IoT system based on a narrow, low-bandwidth network to provide a comprehensive review of food safety monitoring networks. *Table 7* shows the extensive literature review of the use of the IoT in improving food safety in the FSC.

**Table 7. Use of IoT in improving food safety in the food supply chain.**

| Process | Role of the IoT | Impact | References |
|---|---|---|---|
| Improving food safety | Risk | Systems that can increased safety risk and continuous pressure from consumers to deliver high-quality and safe food products | [85]-[89] |
| | High-quality and safe | | [90]-[95] |

### 4.2.5 | Maintaining food quality

Jagtap and Rahimifard [96] stated that various image processing technologies and sensors can help maintain the quality and specifications of raw materials and final products. Barandun et al. [97] designed paper-based electric gas sensors to warn of food quality loss. This system can detect perishable gases emitted from meat. *Table 8* shows the extensive literature review of the use of the IoT in maintaining food quality in the FSC.

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Table 8. Use of the IoT in maintaining food quality in the food supply chain.

| Process | Role of the IoT | Impact | References |
|---|---|---|---|
| Maintaining food quality | Monitoring | Systems that can continuously monitor the product quality and any deviation from the set standards can be immediately notified and rectified | [98]-[103] |
| | Product quality | | [104]-[114] |

### 4.2.6| Transparency of the food supply chain

Skilton and Robinson [115] acknowledged that transparency and traceability are interrelated. They also defined traceability as the process of identifying and validating components and timelines across events in the supply chain. Abad et al. [116] used the smart RFID tag for real-time tracking and cold chain monitoring along a fresh fish logistics chain. Mattoli et al. [117] designed, developed, and tested an IoT-based system to improve logistics during transportation, storage, and sale of wine bottles, as well as their safety assessment. *Table 9* shows the extensive literature on the use of the IoT in the FSC transparency in the FSC.

Table 9. Application of the IoT in the food supply chain transparency in the food supply chain.

| Process | Role of the IoT | Impact | References |
|---|---|---|---|
| Improving FSC transparency | Whole supply chain | Systems that can be caused to better stock management, labor management, reduced costs, and shorter lead times | [118]-[132] |

In general, IoT technology has been around for several years and has reached maturity. Studies show that the benefits of the IoT in the FSC outweigh its disadvantages. As the costs associated with supply chain digitization have been significantly reduced with the advancement of IoT technologies, more food manufacturers are willing to use such technologies. Adoption of this technology leads to long-term benefits and gaining significant market share. The use of IoT technologies in every aspect of the food supply chain helps to optimize and increase the stability of the entire supply chain. Benefits (e.g., better transparency, monitoring, and control of various food operations) enable the IoT to increase production, alert and prevent problems, and perform multiple functions in the FSC automatically.

## 5 | Concluding and Future Suggestions

Internet technology allows the FSC to use dynamic permutation in operations management processes. This support improves food companies in the face of perishable products, unpredictable changes in supply and food safety, and the sustainability required. Virtualization enables supply chain agents to plan and optimize business processes remotely via the internet as virtual objects rather than in a supervised location. In the IoT, FSCs can become a self-adapting system, in which smart objects can be deployed, make decisions, and learn things automatically. In this article, the use of the IoT in the FSC is discussed and several articles from different publishers are scrutinized. Current IoT applications in the FSC are demonstrated and the advantages and disadvantages of the IoT are described. Studies show that IoT has more advantages than disadvantages, so it is recommended that most supply chain actors use IoT technologies. A review of the literature showed that supply chain activities face many problems due to a lack of awareness or availability of accurate real-time data. Monitoring and analyzing the activities of each actor is an essential step towards achieving efficiency and transparency. The availability of credible information is essential to change the various activities in the FSC. By collecting real-time data and analyzing this data, economic and environmental issues can be decided simultaneously, leading to an improved and improved FSC. The cluster analysis in the study of journals shows that researchers should pay more attention to IoT users in terms of product quality and transparency throughout the supply chain, and integrate IT-based systems at each level of the supply chain seamlessly.

## Conflicts of Interest

No potential conflict of interest was reported by the authors.



## Reference

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