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Digitalization in Food Supply Chains: Exploring Opportunities, Challenges, and Pathways to Enhanced Food Security

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ABSTRACT

Food supply chain involves various stages from its harvesting to end consumer but unfortunately, a large proportion of this valuable food got wasted. As food security is a rising concern in this era it is difficult to address this issue without the incorporation of modern technologies. The use of AI, ML, Big Data, Block chain technology and IoT has become necessary to avoid these challenges. This study focuses on how these modern approaches benefit the global food supply with increased food safety and trust among the consumers. However, this review also brings to light potential hurdles for their implementation which must be conquered to unleash their complete prospects.

Keywords: Food supply chain, Digitalization, Food security, Postharvest technologies, Food Loss prevention

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Introduction

Sustainable food supply chains have become a global concern due to the increasing demand of food [1], as the global population is predicted to be reach at 9.7 billion in 2050 [2]. Supply chain typically involves different shareholders from sowing to harvesting, processing to storage and transportation to the final consumer [3]. A large portion of this food got wasted in food supply chain. According to the estimates, a loss of 8% at farms, 14% between farm and retail and 17% at food service and consumption stages, has been recorded [4]. In addition to food losses and wastes, there is also a chance of adulteration which leads to food fraud in the supply chain [5]. So, an overall traceability and digitalization of supply chain is necessary in order to maintain food safety and to keep losses at minimum [6].

The conventional methods of operating FSC are less efficient and labour intensive which in result cause economic and food losses [7] and are not viable in order to meet the SDGs of United Nations concerning food security for the year 2050. To meet these goals, a modern approach in operating food supply chains is required which includes the implementation of IoT [8], Artificial intelligence [9] and block chain technologies [10]. These technologies are not only revolutionizing the food supply chains but also ensuring the greater traceability, transparency, sustainability and operational efficiency. These advances are benefiting both consumers and producers and contributing towards achieving sustainability in FSC [11].

In this review, we will focus on the modern technologies that are playing a crucial part in the advancements of global food supply chains. To achieve the sustainability and reduce the food losses to meet the world food demand it is necessary to incorporate the modern techniques in the food supply chain management. The studies have shown that several technologies are being used in food supply chains. However, these technologies are not easy to implement considering the barriers in their adoption. Table 1 shows some modern technologies for achieving the sustainability in food supply chains.

Table 1: Modern Technologies in food supply chain

Technology	Area	Food Type	Reason of use	Results	References
IOT	Storage	Grains	Monitoring of grains quality according to the given standards	This approach results in the modernization of the storeroom management system, resulting in less food waste and avoidable financial loss.	[8]
IOT and block chain	Farm to consumer	Any	To promote sustainable food supply chains	This promising approach builds consumer trust and provides transparent methods for tracing and tracking the agriculture supply chain of food.	[10]
IOT (Bio-sensing device)	Storage	Non-fresh foods	To avoid diseases	This device can detect whether the food is fresh or not. Moreover, it detects different parameters of food and declares it safe for use.	[12]
IOT (RFID and Machine Learning)	Supply chain	Kimchi	Track product movement, temperature and humidity of food product	Improves the safety and Quality of perishable food product.	[13]
IOT (Biosensors)	Supply chain	Raspberry	Monitoring of food for safety purpose	monitored data helps to take correct decisions to the prevailing condition.	[14]
Artificial Intelligence	Supply chain	Any	To mitigate global food insecurity by implication of AI in global food supply chains	offers promising solutions to overcome the multi-dimensional challenges of food supply chains and create a more sustainable and secure food future	[9]
Artificial Intelligence	Supply chain	Different	Mitigating food fraud by implication of AI tools with other analytical techniques	Detection of fraud get caught using different analytical techniques incorporating artificial intelligence	[15]
Machine Learning	Supply chain	Different	Minimize the food waste and food-borne illness	Ensuring food quality and safety inspection in supply chains	[6]

Modern technologies for Food supply chain:

1. Internet of Things (IoT)

IoT can be defined as a network of physical devices (which are readable, recognisable and locatable) that are connected via different communication means RFID, wireless LAN and wide area networks through internet [16]. IoT has been proved beneficial in operating FSC through its continuous monitoring and tracking of food products in whole food supply chain. Thus,

ensuring the quality and safety of food commodities until these reach to the end consumers [17]. IoT works along with RFID and Biosensors to collect the real-time data of temperature, humidity and deterioration of food products. This approach results in the modernization of food storage system and results in reduced food waste and economic losses [13] [12] [8].

2. Block-chain Technology

The traceability of every single action performed in the supply chain refers to block chain technology [18]. This technology has been recently added for the traceability purpose in the food supply chain after its vast applications in other fields [19]. This technology works in relation with IoT and eliminates the danger of food fraud and ensures food safety. With the help of block chain, every single procedure can be traced back from farm to consumer stage and it develops a sense of trust and relief among the end users. Thus, proving its applications towards developing sustainability in the food supply chains [10].

3. Artificial Intelligence

IoT and block chain have been proved beneficial in food supply chains but there must be a system present to take necessary steps while dealing with the malfunctions [20]. Artificial Intelligence based sensors use real-time data of temperature, humidity and quality control to make decisions to achieve sustainability, reduce food losses and ensures food safety. Moreover, AI tools can help in forecasting any kind of disruptions in SC based on the algorithms. Along with the help of different analytical techniques such as Gas-chromatography, HPLC, FTIR and Mass Spectroscopy, Artificial intelligence can be extremely helpful in detecting food fraud and ensuring the consumer safety [15].

Challenges for the adoption of modern technologies in Food supply chains

Modern technologies have impacted positively on the sustainability goals but there are potential barriers which make it difficult for their implementation. These challenges in implementation are country and technology specific. Inadequate infrastructure, lack of technological use and low-skilled personnel can be crucial factors in developing countries like India [21]. Similarly, BCT has its own limitations which are pivotal to discuss while its execution in an FSC. There is a need to make organizational changes before BCT can applied successfully [22]. Artificial intelligence and machine learning have their applications, but it is not very easy now to achieve this digitalization. Several studies have been conducted using different theoretical models such as DEMATEL and NK model to analyse the potential barriers for AI and big data adoption. Results have shown several factors which should be addressed in order to execute this technology [20] [23]. There is still a lot to discover about big data adoption [23]. Table 2 shows the results of different studies which are highlighting the potential barriers in adoption of these technologies.

Table 2: Problems associated with technologies

Technology	Barriers	Description	References
Big Data	Technological	Complexity, Compatibility, Perceived benefits, Technology resources, Security and privacy	[23]
	Environmental	Competitive pressure, Partners pressure, Government support and policy	
	Organizational	System perspective, Organizational culture, Positive experience with prior IT projects, Management support, Decision-making culture, Change efficiency, and Business strategy orientation	
Block Chain Technology	Quality	Support for the level of details of quality data and data about origin of ingredient to consumer by all actors in the supply chain	[22]
	Traceability	Standard about the level of detail of traceability information that is required to store at defined critical traceability points	
Artificial Intelligence	Economic	Expensive modern technologies are difficult to afford for small sized farm owners	[24]
	Organizational	involves fears of data misuse or losing their competitive advantage	
Machine Learning	Technological	It can't detect the internal compositional changes of food products	[6]

Conclusion

Over the past years, modernization has been indulged to almost every domain so does the global food supply chains. This review meticulously evaluates the role of various studies that are being conducted to ensure the sustainability and incorporation of technologies in FSC such as AI, ML, IoT, Big data and block chain technology have been exhibiting fruitful results. These are transforming the conventional approach to deal global food supply chains. Major concerns of FSC such as traceability, food safety, food losses, temperature and humidity has been addressed in this review. As these technologies are being continuously evolved, these are becoming a crucial part of FSCs. Various factors such as organizational, environmental, economic, lack of knowledge, scalability and modern infrastructure hinders the efficient use of these technologies has been discussed.

In conclusion, these technologies have become an integral part of food systems, and it is a likely solution for us to achieve sustainability and food safety but there is still a lot to discover in order to mitigate the barriers to utilize these to their full potential. The successful integration of these technologies could be our chance to unleash the new dimensions in agriculture advancement and food security

References

[1] Sharma M, Antony R, Vadalkar S, Ishizaka A. Role of industry 4.0 technologies and human-machine interaction for de-carbonization of food supply chains. J Clean Prod. 2024; 468:142922.

[2] Nations U. Global perspective Human Rights. Glob. Perspect. Hum. Rights.

[3] Meena SR, Meena SD, Pratap S, Patidar R, Daultani Y. Strategic analysis of the Indian agri-food supply chain. OPSEARCH. 2019; 56:965–82.

[4] Lipinski B, O'Connor C, Hanson C. SDG target 12.3 on food loss and waste: 2016 progress report. Champions, Washington, DC. 2016.

[5] Onwude DI, Chen G, Eke-Emezie N, Kabutey A, Khaled AY, Sturm B. Recent advances in reducing food losses in the supply chain of fresh agricultural produce. Processes. 2020; 8:1431.

[6] Kang Z, Zhao Y, Chen L, Guo Y, Mu Q, Wang S. Advances in Machine Learning and Hyperspectral Imaging in the Food Supply Chain. Food Eng Rev. 2022; 14:596–616.

[7] Doernberg A, Zasada I, Bruszewska K, Skoczowski B, Piorr A. Potentials and Limitations of Regional Organic Food Supply: A Qualitative Analysis of Two Food Chain Types in the Berlin Metropolitan Region. Sustainability. 2016;8.

[8] J L, S LSV, R M, R M. Automated food grain monitoring system for warehouse using IOT. Meas Sensors. 2022; 24:100472.

[9] Tamasiga P, houssin Ouassou E, Onyeaka H, Bakwena M, Happonen A, Molala M. Forecasting disruptions in global food value chains to tackle food insecurity: The role of AI and big data analytics – A bibliometric and scientometric analysis. J Agric Food Res. 2023; 14:100819.

[10] Hasan HR, Musamih A, Salah K, Jayaraman R, Omar M, Arshad J, et al. Smart agriculture assurance: IoT and blockchain for trusted sustainable produce. Comput Electron Agric. 2024; 224:109184.

[11] Oriekhoe OI, Ashiwaju BI, Ihemereze KC, Ikwue U, Udeh CA. Review of technological advancements in food supply chain management: a comparative study between the US and Africa. Int J Manag Entrep Res. 2024; 6:132–49.

[12] Kumar P, Rawat S. Design and Development of an Application to Preserve Various Eatables Using IoT. Procedia Comput Sci. 2024; 241:415–20.

[13] Alfian G, Syafrudin M, Farooq U, Ma'arif MR, Syaekhoni MA, Fitriyani NL, et al. Improving efficiency of RFID-based traceability system for perishable food by utilizing IoT sensors and machine learning model. Food Control. 2020; 110:107016.

[14] EA N, Tamilarasi D, Sasikala S, Nair RR, Uma KS. WITHDRAWN: An efficient food quality analysis model (EFQAM) using the internet of things (IoT) technologies. Microprocess Microsyst. 2021;103972.

[15] Vinothkanna A, Dar OI, Liu Z, Jia A-Q. Advanced detection tools in food fraud: A systematic review for holistic and rational detection method based on research and patents. Food Chem. 2024; 446:138893.

[16] Patel KK, Patel SM, Scholar P. Internet of things-IOT: definition, characteristics, architecture, enabling technologies, application & future challenges. Int J Eng Sci Comput. 2016;6.

[17] Mohamed Ben-Daya Elkafi Hassini ZB, Banimfreg BH. The role of internet of things in food supply chain quality management: A review. Qual Manag J. 2021; 28:17–40.

[18] Marchese A, Tomarchio O. A Blockchain-Based System for Agri-Food Supply Chain Traceability Management. SN Comput Sci. 2022; 3:279.

[19] Ghiro L, Restuccia F, D'Oro S, Basagni S, Melodia T, Maccari L, et al. What is a Blockchain? A Definition to Clarify the Role of the Blockchain in the Internet of Things. arXiv Prepr arXiv210203750. 2021.

[20] Ghag N, Sonar H, Jagtap S, Trollman H. Unlocking AI's potential in the food supply chain: A novel approach to overcoming barriers. J Agric Food Res. 2024; 18:101349.

[21] Narwane VS, Gunasekaran A, Gardas BB. Unlocking adoption challenges of IoT in Indian Agricultural and Food Supply Chain. Smart Agric Technol. 2022; 2:100035.

[22] Behnke K, Janssen MFWHA. Boundary conditions for traceability in food supply chains using blockchain technology. Int J Inf Manage. 2020; 52:101969.

[23] Yadegaridehkordi E, Hourmand M, Nilashi M, Shuib L, Ahani A, Ibrahim O. Influence of big data adoption on manufacturing companies' performance: An integrated DEMATEL-ANFIS approach. Technol Forecast Soc Change. 2018; 137:199–210.

[24] Konstantina Spanaki Erisa Karafili USSD, Irani Z. Artificial intelligence and food security: swarm intelligence of AgriTech drones for smart AgriFood operations. Prod Plan\& Control. 2022; 33:1498–516.