

An innovative approach towards sustainability by adopting identification technologies in the food sector - A systematic literature review

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ABSTRACT

The food sector around the world is more concerned about food safety and authenticity. A lot of new technologies are being tested by the food industry to achieve the desired results. It is observed that many of the meat production companies are still facing issues with the technology implementation as they are still dependent on the traditional methods of traceability in meat production and meat processing. By doing so, a lot of food waste and delays in processing is the main cause. To understand the requirements and benefits of adopting identification technologies in meat production, a growing body of literature has been examined and analyzed by the authors. By following the PRISMA guidelines 36 articles have been collected from the Science Direct and Web of Science. This paper examines the different aspects in terms of sustainability and economic growth after accepting the identification technologies. According to the systematic literature review findings, this is one of the article that describes the different aspects of technology in the food sector in depth. Mainly, the three different technologies RFID, NFC, and Barcodes are being noticed by the authors in different kinds of literature, which have a huge impact on the sustainability and efficiency of logistic operations. The study found that these technologies in the meat production and meat processing industries have the most value added to the supply chain. The value added by these technologies in the supply chain has a great impact on global and economic levels.

1. Introduction

In food value chains there is a priority of improving the traceability, transparency and efficiency, mainly with the use of the emerging digital technologies (WEF, 2019; EC, 2020). These factors are really important to gain a transparent food production throughout the whole supply chain and contribute those processes (reduce fraud, ensure food safety, improve efficiency in supply chains, reduce food loss) which has a significant role in achieving the Sustainable Development Goals (SDGs) adopted by the United Nations in 2015 (WEF, 2019).

The Farm to Fork Strategy of the European Union is one element to achieve a sustainable food system and ensure food security (EC, 2020) and it has a direct and close relationship with the usage of different identification technologies not only for traceability but also for increasing the performance within and between enterprises.

Considering the entire supply chain, the information flow affects the internal processes of the actors (e.g. packaging, storage) as well as the partnership cooperation of many actors (e.g. farm, distributor, factory, retailer, consumer), therefore digitalization has a great role not only in the integration of internal business processes, but in the information flow between external partners (Ongena et al., 2020). Thus the appropriate digital technologies can support to smooth the information flow of the entire food supply chain. The different applications of the IoT in enterprise business processes can be seen in Figure 1. As

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data shows, the food manufacturing sector (manufacture of food products; beverages and tobacco products) achieved higher level of application almost all indicators, compared to the EU-27 average values of the total enterprise sector (all activities without financial sector).

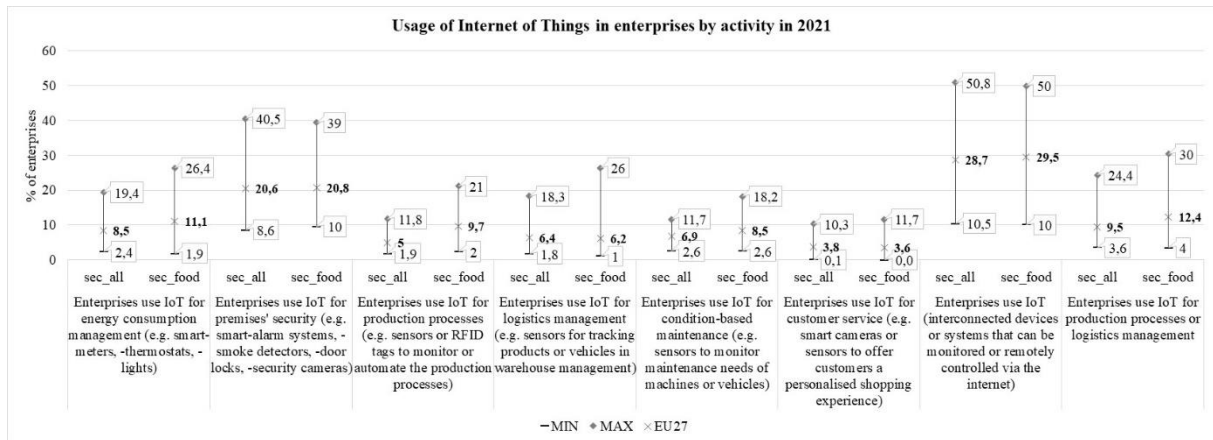


Figure 1. The use of IoT by purposes and activities

(sec_all=All activities without financial sector; sec_food= Manufacture of food products; beverages and tobacco products)

Source: Own edition based on Eurostat, 2021

As a new data source for decision support, the IoT concept refers to objects and devices with sensing and processing capabilities that allow them to communicate with each other and with external systems to achieve a specific goal (Antunes, Gomes, & Aguiar, 2018). New solutions such as IoT (Internet of Things) and BlockChain in the field of food safety are an integral part of the entire agri-food supply chain and we have reached the Agri-food 4.0 concept.

Internet of Things technology can contribute to changes in supply chain processes and data-centric management through decision support tools (Verdouw et al., 2016). By integrating other technologies such as Cloud Computing, Blockchain, Digital Twins and Artificial Intelligence, much more efficient business processes can be created in the supply chain. The level of use of IoT technology is strongly influenced by company size, but sales revenue, the general economic situation of the company and the presence of a foreign owner also matter (NMHH, 2022).

The traditional methods are still being used for the animal identifications not only in the small firms but also in some medium organisations of the meat industry and these industries are still dependent on these methods which includes the bodymarks, earshears and ear tags. (Sgarbossa, Romsdal, Oluyisola, & Strandhagen, 2022) With the advancement of growing technology, various new methods in animal identification have been adopted by the food industries in meat production and meat processing such as RFID, NFC, DNA fingerprinting and retina scan (Kong, Miao et al. 2007). The transmission of animal identity is typically accomplished through edible ink, plastic barcodes, laser engraving, microwave radar, and intelligent trays in the slaughterhouse, despite the fact that quarantine checks are required in some nations (Mousavi et al., 2002).

In this study we analyzed literature related to the following questions:

1. What are the challenges faced by the food sector (meat industry) while implementing the identification technologies?
2. How effective are these identification technologies in terms of information flow within the food companies?

2. Materials and methods

The review was conducted as a systematic literature review. The choice of method is entitled as the title needs the quantitative overview of the existing terminology and the description about the identification technologies used in the food industry. The data was collected from the well-established

academic databases through the online sources which is Science Direct and Google Scholar. The different keyword combinations were discussed and used to find the results. The main goal was to collect all the relevant articles. The authors followed the PRISMA methodology (Moher et al., 2009) to get the accurate results while filtering the papers. Different keyword combinations were tried and tested during the research. The keywords that best defines our research was “Identification technology” and “Food sector” “meat production” and “Identification Technologies” from Science direct along with these RFID in meat processing, NFC technology in meat processing, Barcode in meat production was checked during the process. From google scholar we followed the keyword combination “Sustainability” and “RFID” and “NFC” and “DNA fingerprinting” in food sector quality traceability in meat production were also taken into consideration to find the data. The exact keyword selection is mentioned in the Table 1. Based on the keyword search authors found relevant 36 articles following the PRISMA methodology.

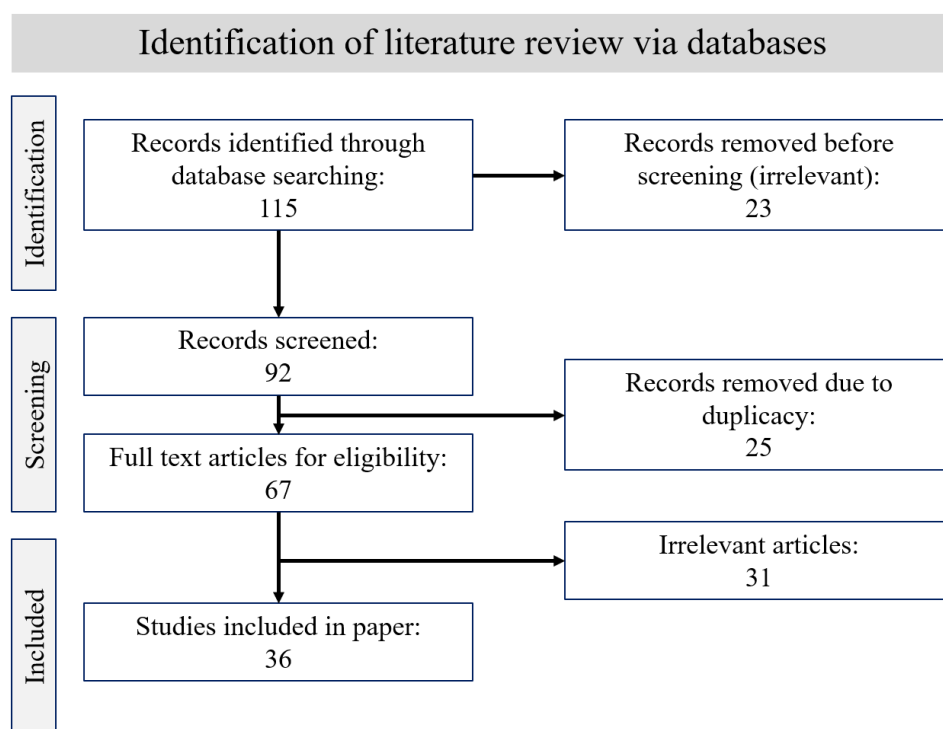


Figure 2. The process of the systematic literature review

3. Results

In this section we present the results we found after reviewing the articles. We come up with various challenges, limitations and benefits while adopting the identification technologies in food sector. The main challenge in this industry while using RFID, NFC and Barcode is loss in information sharing at global levels. These technologies have great value added in the food sector but still loss of information from the livestock has been lost due to lack of knowledge while implementing these technologies. The other major challenge found by the authors is the integration of these technologies with the existing system. Considering the security as a prime goal for various organizations, they believe by implementing the ID technologies can give easy access to the competitors to track the shipments and inventory.

Table 1. Selected articles

Databases	Applied Keywords	Number of articles found (N)	Number of selected articles (n)
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Science Direct	1. "identification technology and "food sector"	57	20
	2. "meat production" and "identification technologies"	27	11
Google Scholar	3. "RFID" and "sustainability" and "NFC" and "DNA fingerprinting" in food sector	8	5
Total		92	36

Source: Author's own edition

The study discusses the different approach to gain sustainability in food sector by implementing the different identification technologies (Sharma-Singh, 2022). Along with the sustainability the two main areas of food industry took main focus by the authors which are meat production and meat processing (Farag et al., 2015).

3.1. Identification technologies in meat production

The different technologies being emerged by the food industry on timely basis to fulfill the needs of the consumers as well as the economic goals (Verdouw et al., 2019). In food industry especially at production level food requires various changes such as product alteration and processing of food materials. Therefore, proper information sharing is required between the supply chains to meet up the demand (Feng et al., 2013). Identification technologies can also impact the efficiency in the meat sector by just implementing the various applications or tracking systems in supply chain. This can also leads to the changes in the inflating rate (Kumar et al., 2019).

Table 2. Use of identification technologies in the food sector (food production and food manufacturing)

Technology	Usage Domain	Information	Reference
Barcode	Meat Processing and food products	Labelling the meat	Thanapal et al., 2017
RFID	Livestock-RFID Tags	Grazing route Accelometer Temperature sensor	Dandage et al., 2017
NFC	Breeding Slaughtering Distribution	Various devices	Sgarbossa et al., 2022

Source: Author's own edition

RFID for traceability

Even though it has been around for decades, Radio Frequency Identification (RFID) has only recently attracted business attention due to its confluence of lower cost and higher capabilities. It has been widely used in a significant meat production inventory tracking and supply chain management since around 2005 (Sabbaghi, Vaidyanathan 2008). To identify items, tags with transponders that emit messages readable by specialist RFID readers are attached to the items. The majority of RFID tags keep data like

an identifying number that a reader gets from a database and uses to take appropriate action (Aslam et al., 2023). Additionally, some RFID tags have writable memory that can be used to store data for transmission to different RFID readers at various places. Each reader will be able to see the movement of the tagged object information (Stranieri et al., 2021). According to their source of electrical power, RFID tags can be divided into two main categories: active and passive (Weinstein, 2005). Table 3 describes best of the detailed description of the RFID tags which is used for various operations in supply chain (Kerry et al., 2006). RFID tags on agricultural products allows farmers to get to know the quality of the products produced in the farm and also it adds value to the company by delivering the exact data which is clearly mentioned on the RFID tags (Vashisht et al., 2022). But also the radio frequency identification technologies implementation is different for different organisations especially when the organisation is using the different layouts in the same organisation (Sarkar et al., 2022). But also believed that in some companies knowledge based implementation of various technologies gives more profit to the organisation and also gives more food security in terms of various factors (Sgarbossa et al., 2022). Technology advancement is taking a wide range and also it can provide various solutions to the companies that have high value chains and also it can impact the businesses globally with these transparent technologies (Corallo et al., 2020). Especially in the food supply chain the RFID tags not only track the movement of the products but also it will check the humidity, temperature and condition of the product which is the main benefit to the food supply chain (Ganjar et al., 2020). By this the sustainable supply chain might be implemented and which will definitely leads to the economic growth for various countries (Qian et al., 2020).

Table 3. RFID tags

RFID Tags	Usage domain	Power source	Frequency	Reference
Active Tags	For large items tracked from far distances	uses its own power source	455MHz, 2.45GHz or 5.8GHz	Weinstein, 2005 Behnke-Janssen, 2020
Passive tags	Depends on the Tag size, it can track the nearest possible and if the tag is larger it can also track from farther places	It does not have any power source, It only transmit the RFID signals when receiving a radio frequency energy from an RFID from that range	128KHz, 13.6MHz, 915MHz or 2.5GHz	Weinstein, 2005 Angelo, 2020 Singh et al., 2019

Source: Own edition

Using NFC in meat production

Future technology called Near Field Communication (NFC) was created over RFID. A recent development makes it possible for devices to share information at a maximum data rate of 424kbps using a contactless, wireless communication link that is a maximum of four centimeters away from each other (Farag et al., 2015). The technology makes it simple for food industry at production levels to handle data for internal use and to satisfy the demands of the regulatory authorities. Every step of the food supply chain—production, processing, distribution, retail, and consumer involves the use of NFC and cloud storage (Pigini-Conti, 2017).

As a result, it guarantees an immediate and precise trace-back when required. Additionally, the use of NFC technology improves food safety for both the final consumer and the representatives of each stage of the supply chain (Alfian et al, 2020). The different apps used by the food industry can also encourage quality manufacturing and sustainable production, which will boost consumer confidence (Bibi et al., 2017).

NFC offers additional communication options over RFID because, as was already mentioned, it is more recent. NFC's primary characteristic that sets it apart from RFID is that it prepares bidirectional

data (Costa et al., 2013). NFC and RFID differ primarily in how they prepare data for bidirectional transfer between NFC-enabled devices, which is the key differentiator between the two technologies (Sgarbossa et al., 2022). It only takes a slight physical touch or proximity between the two objects for the two devices to communicate. The NFC protocol then forms a peer-to-peer link automatically, allowing the devices to operate in passive or active mode similarly to RFID technology (Yordanov-Angelova, 2006).

Electronic identification, DNA profiling for traceability

Regardless of whether the meat is fresh or cooked, DNA fingerprint identification uses the inbuilt barcode found in all animals to identify a specific animal farm from the farm to the table. Multiple allele microsatellites are used for identification (Bai et al., 2017). In a total of nine studies, IDEA project was conducted in six nations Germany, Spain, France, Holland, Italy and Portugal. The major goals were to understand the organizational structure and also to implement and evaluate the performance of an electronic identification system in ruminants (sheep, cattle, buffalo and goat) and also to identify the needs of the organizational structure to implement such level of system for EC livestock (Amuno, 2020). The IDEA project proved that an EID system may significantly enhance the livestock identification, registration and management across the community (Furness, 2006). Traceability is part of the risk management which can also help or leads to the benefits of the food sector but the initiative must be taken by the department (Gartner et al., 2021).

3.2. Limitations and benefits of using the identification technologies

In addition, most businesses in meat industry have more than one chain. They have numerous, some of which are networks. It is observed that there are approximately sixteen different types of supply, according to their commercial impact and complexity. Supply chains can be very simple or quite complex in terms of complexity, and depending on their impact on business, they can be quite conventional or have a competitive advantage (Sabbaghi-Vaidyanathan, 2008). The Identification technologies has a great impact on food chain and companies gain a huge profit by implementing them with different structures because of the improved advanced structures businesses are growing rapidly (Stranieri et al., 2021). There are some companies believe that the massive data produced by these devices is not that easy to handle and can create the complex structure which is one of the limitation in the organisations (Antunes et al., 2018). The benefits and limitations from these technologies has been discussed by the different authors in different papers.

Table 4. Benefits and limitations of identification technologies

ID Technologies	Benefits	Limitations	ReferenFce
RFID	Highest Accuracy	Uncertain at some points and high cost	Kaulen et al., 2023 Qian et al., 2020
DNA Fingerprinting	Highest Accuracy in the improvement status of the various crops	High cost and may limit the process	Wossen et al., 2019 Zhao et al., 2020
NFC	-High performance with ease of reading. -Not effected by environment	Advanced implementation requirements	Jagtap et al., 2021 Thanapal et al., 2017 Fabien Bibi, 2017

4. Conclusions

In this article we have come across with various important points of traceability in the food industry. The literature review conclusions demonstrate that identification technologies have a great impact on

food sector and also have shown great potential from the previous years. The food sector is taking huge advantage from the advancement of technology from the previous years. Identification technologies have a huge impact on the organisations and these technologies has a potential uses in different application's. We found the advantages of these identification technologies in various studies lead to their implementation in different food companies. On the other hand, the drawbacks of these technologies might put a question to the organizations whether to choose them or not. As some of the studies state, there are many challenges such as financial, complex structures and inaccurate data when it comes to implementing RFID, NFC and DNA fingerprinting in different ways.

The trend towards IoT has already started in the food industries, the analysis of which is also an important task. Combining existing traceability technologies with IoT will bring a big change in the entire food supply chain. Also by overcoming the challenges in the field of the meat industry or food industry, these technologies will help the organisations in terms of sustainability and an efficient supply chain.

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