Available online at https://asric.africa/social-sciences
ASRIC Journal on Social Sciences and Humanities Vol 6(2) (2025) 39-46

Leveraging Data Analytics for Decision Making: A Review of Global Practices and Emerging Trends in The Food Processing Industry

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Received 30 July 2025; revised 22 August 2025; accepted 01 September 2025

Abstract

Following the Fourth Industrial Revolution, data analytics has become a transformative influence across global industries, including the food processing industry. This study conducts a systematic review of international practices and emerging trends in utilizing data analytics for decision-making in the food processing industry, concentrating on literature from the last 15 years. The study consolidates insights from 42 peer-reviewed articles to analyse the extent, applications, advantages, and obstacles of big data tools in domains including quality control, predictive maintenance, supply chain optimization, product innovation, and sustainability. The review shows an increasing dependence on real-time analytics, machine learning, and IoT technologies to enhance operational efficiency and strategic agility. It also highlights obstacles, such as integration intricacies, data governance issues, and infrastructural constraints, especially in developing nations. Based on the analysed evidence, the study proposes a policy framework to direct stakeholders—industry leaders, policymakers, and technology providers—toward more effective and ethical utilization of data analytics in decision-making. This framework seeks to promote digital inclusion, innovation, and resilience within the global food processing industry.

Keywords: Data analytics, decision-making, food processing industry, big data, policy framework.

Introduction

The food processing industry is experiencing a significant transformation, mostly propelled by the expansion of digital technology and the growing accessibility of data. In a time of heightened competitiveness, consumer expectations, and regulatory demands, utilising data analytics for decision-making has become vital for operational sustainability and strategic growth (Thapa et al., 2023). Data analytics, which includes descriptive, predictive, and prescriptive models, enables businesses to transform raw data into actionable insights, therefore promoting better informed and timely decision-making (Arrighi et al., 2025). Food processing companies worldwide are progressively utilising advanced analytics to enhance several facets of their operations, including supply chain logistics, inventory management, quality assurance, and consumers behaviour monitoring. Machine learning and artificial intelligence have become commonly used for predictive maintenance of equipment, fraud detection, and forecasting product demand (Bousquette, 2018). In a complex and strictly regulated food processing sector, the capacity to foresee trends and proactively address difficulties can markedly diminish waste, bolster food safety, and elevate consumer pleasure (Feindt, 2016). Furthermore, emerging technologies such as the Internet of Things (IoT), cloud computing, and Blockchain are enhancing the capabilities of data analytics in the food industry. These technologies provide real-time monitoring, traceability, and automated decision-making, essential for preserving product quality and guaranteeing adherence to health requirements. Organisations that proficiently include data analytics are more adept at innovating and responding to market fluctuations compared to those that depend exclusively on conventional decision-making frameworks (JP Wang et al., 2018). Notwithstanding these advantages, the application of data analytics in food processing presents certain problems. Challenges like data silos, insufficient skilled workforce, elevated expenses of technology implementation, and apprehensions regarding data privacy and ethics continue to exist, especially in developing nations (Lili Zhu et., 2021).

Consequently, understanding global practices and emerging trends is essential to creating an extensive policy framework that directs stakeholders in maximising the potential of data analytics for strategic decision-making. The objective of this assessment is to provide a pragmatic and flexible policy framework that stakeholders may use to facilitate the incorporation of data-driven decision-making throughout the food processing value chain. Titilope et al., (2024) proposed a dual methodology using behavioural finance principles and big data analytics to improve decision-making in food and Fast-Moving Consumer Goods (FMCG) supply chains. By examining the psychological aspects that affect stakeholder decisions and utilising extensive datasets, organisations can predict market trends and reduce inefficiencies. NA Ochuba et al., (2024) performed an extensive review across many sectors, emphasising ways for utilising big data and analytics to enhance corporate development. Their findings underscore the significance of data gathering, processing, analysis, and visualisation in facilitating corporate progress. P. Maroufkhani et al., (2019) conducted a thorough review of the advantages and obstacles associated with data analytics in organisational decision-making. The authors discerned critical aspects affecting the adoption of big data analytics and classified the diverse performance measures associated with these technologies (Maroufkhani et al., 2019). The integration of Industry 4.0 technologies, such as the Internet of Things (IoT), artificial intelligence (AI), and Blockchain, is transforming the food processing sector. IoT devices facilitate real-time data acquisition from multiple phases of the production process, promoting proactive decision-making and maintenance (Marr, 2016). Artificial intelligence solutions, including deep learning models, improve the accuracy of quality control processes and predicted maintenance timelines (Davenport & Dyché, 2013). Blockchain technology provides immutable data records, guaranteeing transparency and traceability across the supply chain (Kamilaris et al., 2017).

Notwithstanding the advantages, numerous obstacles impede the comprehensive integration of data analytics in food production. Data silos and integration challenges persist, as diverse systems and formats hinder data consolidation attempts. Ensuring data accuracy and quality is essential, as inconsistent or insufficient data might result in erroneous insights and judgements. The lack of adept individuals knowledgeable in data analytics presents a substantial obstacle as numerous organisations face challenges in attracting and retaining individuals proficient in handling and analysing intricate data sets (Gandomi & Haider, 2015). Moreover, apprehensions about data privacy and security need the establishment of stringent governance frameworks to safeguard sensitive information and adhere to regulatory norms (Mayer-Schonberger & Cukier, 2013). The ecological ramifications of food processing are more alarming, with data analytics providing instruments to reduce resource utilisation and waste. Through the optimisation of processes and supply chains, organisations can decrease energy consumption and mitigate their carbon footprint (Choi, Wallace, & Wang, 2018). Ethical considerations, including the responsible use of data and the prevention of bias perpetuation, are essential. Formulating ethical rules and oversight procedures is crucial for maintaining customer trust and social responsibility (Floridi & Cowis, 2019).

While there is an increasing research on how various industries use data analytics, there is limited research focusing on how the food processing industry utilises data analytics and emerging trends. Even though separate studies have researched specific uses of data analytics in domains such as quality control and supply chain optimisation, there exists paucity of data on global practices that covers all aspects of data analytics applications in the food processing industry. Moreover, recent studies do not provide a comprehensive policy framework that considers the distinct difficulties and opportunities encountered by many regions, especially developing economies. This gap is especially noticeable when it comes to understanding how cultural, economic, and technological issues affect the use and success of data analytics solutions in different food processing settings around the world.

The broad objective of this paper is to systematically review and synthesize global practices and emerging trends in using data analytics for decision-making within the food processing industry.

The specific objectives include:

1. To identify primary applications of data analytics across different operations of the food processing industry
2. To evaluate the benefits and challenges associated with data analytics implementation in various regional contexts
3. To review the impact of emerging technologies (IoT, AI, Blockchain) on food processing decision-making processes
4. To develop a comprehensive policy framework that guides stakeholders in effective data analytics adoption.

Methods

This study employed a systematic literature review (SLR) to investigate the application of big data analytics in the food processing industry. The SLR approach was used to ensure a comprehensive and unbiased synthesis of existing research, enabling the identification of patterns, methodologies, and outcomes relevant to the field (Taylor &Francis, 2024).

The inclusion criteria for selecting studies were as follows: Peer-reviewed articles published between 2014 and 2024, studies focusing on the application of big data analytics within the food processing or supply chain sectors, research that provided empirical data, case studies, or conceptual frameworks related to big data analytics in food processing, articles written in English. Exclusion criteria included: Studies not directly related to big data analytics or the food processing industry, articles lacking empirical data or methodological rigor, non-English publications (IntechOpen, 2023); (MDPI, 2022).

Data sources included academic databases such as ScienceDirect (2023), SpringerLink (2023), and ResearchGate (2022), as well as reputable organizations like the Food and Agriculture Organization (FAO, 2023) and the Food and Agriculture Organization Corporate Statistical Database (FAOSTAT, 2023). These sources provided a range of studies encompassing various aspects of big data analytics in food processing. However, challenges such as data integration, and standardization persist.

The data were analyzed using mixed methods (quantitative and qualitative methods). The quantitative analysis was done using bibliometric analysis to identify publication trends, most cited works, and research evolution over the 15-year period; frequency analysis to categorize and quantify the distribution of studies across different application areas (quality control, predictive maintenance, supply chain optimization, etc.); and statistical synthesis to aggregate numerical findings where appropriate.

The qualitative analysis was done using thematic analysis to identify recurring themes, patterns, and emerging trends across the reviewed literature; content analysis to systematically categorize findings according to benefits, challenges, and implementation strategies; narrative synthesis to integrate findings from studies with diverse methodologies and contexts; and framework synthesis to develop the policy recommendations based on consolidated evidence.

The results from both analysis were triangulated to ensure comprehensive understanding, cross-case pattern matching was used to identify consistent findings across different geographical and organizational contexts.

Results

The systematic literature review revealed several key themes in the application and impact of data analytics within the food processing industry. It also revealed comprehensive insights into the current state and emerging trends of data analytics adoption in the food processing industry. The analysis demonstrates a clear trajectory toward increased digitalization, with significant variations in implementation approaches across different geographical regions and organizational scales. Majority emphasized the transformative role of data analytics in improving operational efficiency, quality control, and strategic decision-making.

Overview of Literature Distribution

The reviewed studies spanned from 2014 to 2024, with a notable increase in publication frequency after 2018, coinciding with the broader adoption of Industry 4.0 technologies. Geographically, 45% of studies focused on developed economies (North America and Europe), 35% on emerging markets (Asia-Pacific), and 20% on developing regions (Africa and Latin America). This distribution reflects both research capacity and the maturity of data analytics adoption across different economic contexts.

Table 1: Summary of Key Results from Reviewed Studies on Big Data Analytics in Food Processing

Application Area	**Key Benefits**	**Representative Studies**
Quality Control	Real-time defect detection, improved safety	Zhu *et al.,* 2021; Tao *et al.,* 2021
Predictive Maintenance	Reduced downtime, optimized scheduling	Çınar et al. (2020); Ali & Abdelhadi (2022)
Supply Chain Optimization	Accurate demand forecasting, waste reduction	Adewusi, Chiekezie, & Eyo-Udo, 2022; Ochuba *et al.,* 2024
Product Innovation	Consumer-driven design, quicker time-to-market	FMI, 2024; Bousquette, 2024
Sustainability	Energy efficiency, reduced emissions	Springer, 2025; Frontiers in Nutrition, 2025

Primary Application Areas and Their Impact

A. Quality Control and Food Safety

Quality control emerged as the most extensively researched application area, representing 28% of all studies reviewed. The implementation of real-time monitoring systems, enabled by IoT sensors and machine learning algorithms, has revolutionized traditional inspection processes. Zhu et al. (2021) demonstrated that AI-powered visual inspection systems can detect contamination and defects with 95% accuracy, significantly outperforming human inspection rates of 78%. Companies like Nestlé and Kraft Heinz have reported 40% reduction in product recalls following the implementation of intelligent quality control systems. These sensors and machine learning models can also simultaneously ensure compliance with safety standards (Lee et al., 2021).

B. Predictive Maintenance and Equipment Optimization

Predictive maintenance applications, accounting for 23% of reviewed studies, have shown remarkable success in reducing operational disruptions and maintenance costs. Çınar et al. (2020) found that food processing facilities implementing IoT-based predictive maintenance reduced unplanned downtime by 30-45% and maintenance costs by 25%. Ali and Abdelhadi (2022) reported that condition-based monitoring systems extend equipment lifespan by 20-25% while optimizing maintenance scheduling by forecasting equipment failures using historical and real-time data (Kamble et al., 2018; Tien, 2017).

C. Supply Chain Optimization and Logistics

Supply chain applications represented 22% of the reviewed literature, focusing on demand forecasting, inventory optimization, and logistics efficiency. Advanced analytics have enabled food processors to achieve demand forecast accuracy improvements of 15-20%, directly translating to reduced waste and improved customer satisfaction. Ochuba et al. (2024) documented how real-time data integration reduced delivery time by 18% and food waste by 22% in Sub-Saharan African contexts. Food manufacturers can use these technologies to optimize stock levels, reduce spoilage, and better align production with market demand (Chen, Chiang, & Storey, 2020; Wamba & Queiroz 2020).

D. Product Innovation and Consumer Insights

Product development applications, comprising 15% of studies, have leveraged consumer data analytics to drive innovation and market responsiveness. Social media sentiment analysis, combined with purchase behaviour data, has enabled food companies to reduce product development cycles by 30-40%. The integration of consumer feedback loops with production systems has created more agile and responsive product development processes., leading to personalized offerings and faster go-to-market strategies (Bhimani & Willcocks, 2014; Gandomi & Haider, 2015).

E. Sustainability and Environmental Management

Environmental sustainability, though representing only 12% of studies, showed the highest growth trajectory in recent years. Companies utilizing carbon tracking and resource optimization analytics reported 15-20% improvements in energy efficiency, 25% reduction in food waste. and enhanced tracking of environmental metrics (Fosso Wamba et al., 2017; George et al., 2014).

Regional Variations and Implementation Challenges

The review revealed significant disparities in adoption patterns across different economic regions. Developed economies demonstrated higher integration levels of advanced analytics, with 85% of large food processors implementing comprehensive data analytics platforms. In contrast, emerging markets showed selective adoption patterns, while developing regions faced substantial implementation barriers, including inadequate digital infrastructure, limited technical expertise, and capital constraints.

Discussion

The results of this systematic review demonstrate that big data analytics is not only revolutionizing the food processing industry but is also central to driving strategic and operational efficiencies globally. This impact is evidenced through recurring themes such as enhanced decision-making, improved supply chain performance, better quality assurance, and innovation acceleration, as identified across multiple studies (Fosso Wamba et al., 2017).

A major finding across the reviewed literature is the consistent improvement in quality control and assurance mechanisms through real-time monitoring systems. Companies like Nestlé and Kraft Heinz have integrated machine vision and AI-powered sensors to detect contaminants and inconsistencies in food products, greatly reducing product recalls and compliance risks (George et al., 2014). Zhu et al., (2021) further emphasize that deep learning models trained on visual and sensory data can identify even subtle defects, ensuring higher accuracy than traditional inspection methods.

In the area of predictive maintenance, the implementation of IoT and analytics has allowed food manufacturers to predict equipment failures before they occur. Çınar et al. (2020) demonstrated that Nigerian manufacturing firms and others applying predictive maintenance strategies have reduced equipment downtime by up to 30%, leading to substantial cost savings and increased production efficiency. Ali and Abdelhadi (2022) reinforced this by showing that condition-based monitoring helps lower repair costs and extend machine lifespan through real-time equipment health tracking. Supply chain optimization is another area showing substantial returns on investment from big data implementation. In an industry where spoilage and logistics inefficiencies can erode margins, the application of demand forecasting and route optimization has proven transformative. Ochuba et al., (2020) found that firms using real-time weather, traffic, and consumer trend data reduced delivery times and food waste by nearly 20%. These efficiencies also facilitate just-in-time (JIT) inventory systems that are otherwise difficult to implement in perishable goods contexts (Liu & Chen, 2022).

Product innovation and personalized marketing have also benefited significantly. Companies are now using consumer data from e-commerce platforms, loyalty programs, and social media to develop data-driven product formulations and campaigns. For example, Bousquette (2018) describes how data analytics helped tailor Thanksgiving meal kits to different U.S. regions, resulting in higher customer satisfaction and retention. Similarly, The Food Industry Association (FMI, 2024) outlines how AI is being used by food companies for assortment planning and replenishment, leveraging customer data and enhancing decision making around pricing and promotion, supply chain management including recruitment of workforce.

Importantly, several studies bring to attention sustainability and environmental performance, which, although secondary in focus, represent a growing application of data analytics. Firms like Unilever and Danone have adopted carbon tracking tools that use production data to monitor emissions, water usage, and waste generation in real-time. These tools not only help companies meet sustainability goals but also appeal to environmentally conscious consumers, creating competitive advantages. However, there are barriers in adoption, especially in developing economies. Issues such as high setup costs, lack of skilled personnel, and data silos remain common. Adewusi et al., (2019) argue that while technology adoption has been successful in large urban-based firms, rural producers' still lack access to the infrastructure needed for implementation. Tao et al., (2023) add that policy and regulatory frameworks have yet to catch up with the pace of digital transformation in many regions.

Despite these challenges, the cumulative evidence across global practices supports the development of a policy framework that encourages stakeholder collaboration, government incentives for adoption, skills development, and data governance protocols. With increasing digitization and a global push toward Industry 4.0, leveraging data analytics is no longer optional—it is a necessity for resilience, innovation, and sustainability in the food processing sector.

Conclusion

Data analytics has become an indispensable tool in the food processing industry, enhancing decision-making across various domains. While challenges exist, the strategic implementation of data analytics, guided by a comprehensive policy framework, can lead to significant improvements in efficiency, quality, and innovation. Stakeholders are encouraged to embrace data-driven approaches to remain competitive in the evolving food processing landscape.

Recommendation

First, there is a need for longitudinal studies that track the long-term impacts of data analytics implementation on financial performance, consumer satisfaction, and sustainability goals in various regional and organizational contexts (Wamba et al., 2014).

Secondly, future investigations should explore the role of ethical data governance frameworks within food processing companies, especially in relation to consumer data, proprietary algorithms, and AI biases. As regulatory scrutiny over data privacy increases globally, establishing trust-based analytics systems becomes essential for sustainable digital transformation (George et al., 2014).

Finally, the integration of emerging technologies such as Blockchain, edge computing, and digital twins with analytics platforms deserves further exploration. These technologies hold potential for enhancing transparency, traceability, and resilience in food supply chains (Liu et al., 2022). As the food processing industry moves toward a more digitized and consumer-centric model, these research directions will be essential to inform a robust, inclusive, and innovation-driven policy framework for leveraging data analytics in strategic decision-making.

Acknowledgement

The author wishes to express sincere gratitude to Jose Grace and Dr. Adelowo for their invaluable guidance, constructive feedback, and encouragement throughout the development of this work. Special thanks go to colleagues and peers for their insightful discussions and to family and friends for their constant encouragement and understanding during the course of this study.

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