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Artificial Intelligence in Food Processing: The Nigerian Experience

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Abstract

Artificial Intelligence (AI) is fundamentally reshaping the food processing industry by optimising operations across the entire value chain, from raw material sourcing to final distribution. This transformative impact is evident in areas such as production efficiency, stringent quality control, streamlined packaging, and enhanced distribution networks. For the Nigerian food processing sector to fully leverage these substantial benefits, a collaborative effort among all stakeholders is imperative to accelerate AI integration. While some pioneering Nigerian food processors have initiated AI adoption, the sector has barely begun to tap into AI's vast potential. The applications of AI in food processing are extensive, offering numerous advantages to the industry. However, significant obstacles impede the widespread adoption of AI in Nigeria. These challenges include a scarcity of skilled technical expertise in AI and data science, inadequate access to essential infrastructure like reliable internet connectivity and robust data storage solutions, concerns regarding data privacy and security, and the considerable initial investment costs associated with AI technologies. Despite these hurdles, the Nigerian food processing industry stands to gain immensely from AI. Government initiatives, strategic academic-industrial partnerships, and improved access to funding are crucial for cultivating an environment conducive to AI adoption. Through strategic investment in AI, Nigeria's food processing sector can significantly enhance its domestic competitiveness and solidify its position as a key participant in the global food market. This review therefore explores the diverse applications of AI in food processing, alongside the advantages, opportunities, and challenges specific to the Nigerian food processing sector.

Keywords: Artificial intelligence, Food processing, Robotics, Raw materials, Nigeria

Highlights

- Artificial Intelligence (AI) is rapidly becoming indispensable in the food processing industry.
- Integrating AI offers substantial opportunities for innovation and efficiency.

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Introduction

Global population projections indicate a rise to 9.8 billion by 2050 and 11.2 billion by 2100 (UN Reports, 2017). This anticipated growth will inevitably lead to a significant increase in the demand for food (FAO, 2024). This growth is projected to exacerbate global hunger, particularly in developing nations within Sub-Saharan Africa. Currently, approximately 1 in 11 people worldwide experience hunger, a figure that rises to 1 in 5 in Sub-Saharan Africa (FAO, 2024). Moreover, the G20 Global Alliance Against Hunger and Poverty Task Force's 2024 report cautioned that the world is significantly off track to achieve SDG 2: Zero Hunger by 2030 (Mohammed, 2023). This underscores the critical need to address the escalating global hunger crisis and boost food production to adequately feed the rapidly expanding population (Ikram *et al*., 2024). Consequently, global governments and policymakers have concluded that eradicating hunger necessitates innovative solutions that go beyond conventional food production and processing methods (Dakhia *et al*., 2025). A multifaceted approach, transcending the age-long techniques in food processing and preservation is thus poised to transform the agrifood system at a rapid pace, and make healthy diets more affordable and accessible, and is largely anchored in the groundbreaking innovation of Artificial Intelligence (AI) (WFP, 2025).

Artificial Intelligence (AI) is rapidly becoming indispensable in the food processing industry. Its ability to mimic human-like operation and reaction allows for the rapid, real-time execution of diverse tasks, a capability that is increasingly vital

for the sector (Taneja *et al*., 2023). The past two decades have witnessed an unprecedented acceleration in AI development, pushing its capabilities far beyond earlier predictions.

This review highlights AI's critical role in enhancing productivity within the food processing industry. It specifically demonstrates how AI can effectively address the sector's most pressing challenges. Ultimately, this study aims to provide actionable insights and guidance for governments, researchers, and food industry professionals, thereby encouraging and accelerating the development and adoption of AI technology in food production and processing.

Literature Search

For this review, a systematic and thorough literature search was conducted across three prominent academic databases: Web of Science, Scopus, and Google Scholar. The search strategy involved comprehensive terms related to the application of Artificial Intelligence (AI) within the food processing industry. To ensure a focused collection of relevant materials, the search was constrained to document types classified as "article", paper" or "review" and encompassed all recent publication years up to the present. Following the initial search, duplicate entries were meticulously consolidated. Subsequently, research papers and reviews specifically investigating AI-powered food processing were critically selected for inclusion in this review.

What is Artificial intelligence (AI)?

Artificial Intelligence emulates human intelligence through machine learning, enabling machines to analyse, interprete, and understand complex data and behaviours. This is evident in applications like natural language processing, computer vision, and speech recognition (Russell & Norvig, 2021). At its core, AI strives to replicate and even surpass human cognitive functions. It achieves this by employing advanced algorithms and models to empower machines to analyse vast datasets, identify intricate patterns, and subsequently generate predictions or execute actions based on these insights (Wu *et al*. 2025). As depicted in Fig. 1, Artificial intelligence encompasses several key areas such as: machine learning (ML), deep learning (DL), natural language processing (NLP), computer vision (CV), robotics, and cognitive computing.

Machine Learning (ML): represents a transformative approach to artificial intelligence, empowering systems to acquire knowledge and make decisions through data analysis rather than explicit programming. Unlike traditional methods that depend on predefined rules, ML algorithms are trained on extensive datasets (Russell & Norvig 2021). This training process allows them to identify patterns, discern correlations, and generate accurate predictions or classifications.

Deep Learning (DL): This is a specialised subfield of machine learning, leveraging artificial neural networks composed of multiple hidden layers—hence the "deep" in its name—to autonomously identify intricate patterns within vast datasets. These sophisticated models, drawing inspiration from the human brain's interconnected structure and functional mechanisms, have demonstrated exceptional performance in diverse applications. Their remarkable success in areas like image recognition, and speech recognition stems from their inherent capacity to automatically extract high-level, abstract features directly from raw input data (Onyekpe et al., 2025).

Natural Language Processing (NLP): This AI field focuses on enabling computers to comprehend, interpret, and generate human language. Practical NLP applications include language translation, sentiment analysis, conversational chatbots, and voice-activated assistants (Jansen *et al.,* 2023).

Computer Vision (CV): Computer vision aims to equip machines with the ability to "see" and understand visual information from their surroundings, much like humans do. This encompasses tasks such as identifying objects, classifying images, recognising faces, and analysing medical imagery (Abirami, 2025).

Robotics: While distinct, robotics frequently integrates AI capabilities. This integration allows robots to perceive their environment, make autonomous or semi-autonomous decisions, and execute complex physical tasks (Pandy *et al*., 2025).

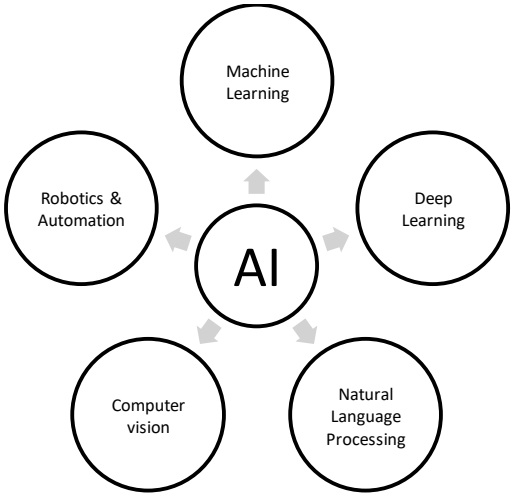

Figure 1: The core components of Artificial intelligence

The role of AI in food processing

Food processing encompasses any action or procedure that alters the initial form of raw food materials. This transformation involves a series of physical and/or chemical operations utilising equipment, energy and tools (Kramer, 2019; Nengnong & Ripnar, 2025). It could involve a single process or a combination of methods, such as cleaning, washing, grading, chopping, milling, pasteurising, freezing, fermenting, packaging, heating, extruding, adding ingredients to extend shelf life or transporting food items (EUFIC, 2024). Food processing also refers to the multifaceted activity of conversion of ingredients or raw agricultural products into edible food items or products. This broad definition means food processing occurs across various settings: at home, in out-of-home establishments like restaurants and cafeterias, and on an industrial scale. Consequently, the majority of foods consumed daily are processed to some degree (IFT, 2024).

Given the intricate nature and expansive scale of modern food processing, integrating AI offers substantial opportunities for innovation and efficiency across various facets (Fig. 2):

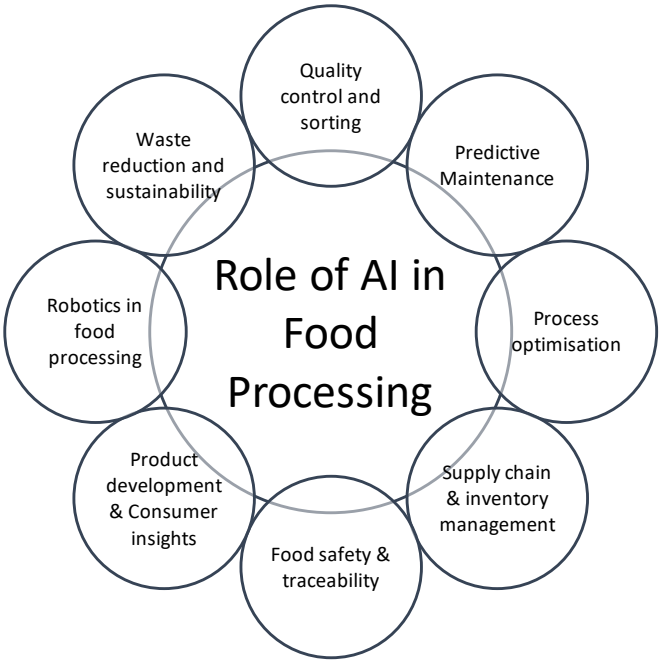

Figure 2: The Role of AI in Food Processing

Quality Control and Sorting
AI-enabled vision systems and sensors are revolutionising food processing plants by meticulously inspecting and sorting food items based on attributes like shape, size, color, texture, and the presence of defects. This includes tasks such as identifying bruised or discolored fruits and vegetables, detecting contamination or foreign materials in packaged goods, and ensuring uniformity in product size and appearance. These systems significantly reduce human error while boosting production consistency and efficiency (Dhal, 2025; Jayan *et al*., 2025).

Predictive Maintenance
AI models are highly effective in predicting equipment failures within food processing plants. Sensors continuously collect data on parameters such as temperature, pressure, vibration, and energy consumption. Machine Learning algorithms then analyse this data to anticipate wear and tear, enabling preemptive machinery maintenance, thereby minimising costly downtime and preventing expensive repairs (Jangra *et al*., 2025).

Process Optimisation
AI algorithms are instrumental in optimising food production processes by analysing critical variables like temperature, humidity, mixing time, and ingredient ratios. This optimisation leads to improved yield, reduced energy consumption, and consistent product quality. For instance, AI can determine the ideal fermentation time in dairy or beverage production to maximise both flavour and shelf life (Li *et al.,* 2025).

Supply Chain and Inventory Management
AI significantly enhances supply chain efficiency through accurate demand forecasting, streamlined inventory management, and optimised delivery routes. The benefits are far-reaching, including reduced food wastage by aligning production with real-time demand, minimised storage costs, and timely delivery of both raw materials and finished goods. Furthermore, AI systems can proactively detect potential supply chain disruptions, such as raw material shortages or transport delays, and suggest corrective measures (Dhal, 2025).

Food Safety and Traceability
Ensuring food safety is paramount in agro-food processing, and AI plays a crucial role. AI-integrated blockchain technology enables robust traceability, tracking food products from the farm to the consumer's table. AI systems also analyse sensor data to detect microbial contamination or toxic substances early in the process. Moreover, AI software helps ensure all food processing activities comply with stringent health and safety standards set by regulatory bodies (Yin *et al.,* 2025).

Product Development and Consumer Insights
AI significantly aids in the development of new food products by analysing market trends, nutritional data, and consumer preferences. For example, AI systems equipped with several sensors for real-time detection such as electronic nose (E-nose), electronic tongue (E-tongue) can predict consumer preferences based on flavour, texture, and taste (Manavi *et al*., 2022). Food companies can also leverage AI to simulate new recipes without actual cooking, leading to substantial savings in research and development costs (Kuhl, 2025).

Robotics in Food Processing
AI-powered robots are revolutionising food processing by taking over tasks that are repetitive, hazardous, or labor-intensive. Their capabilities include precision cutting, peeling, and deboning of meat, as well as efficient packing and palletising of goods. These robots can also operate effectively in extreme environments, such as freezing rooms (Rayhan, 2023). The adoption of robotics not only enhances production efficiency but also significantly reduces workplace injuries. By integrating AI technology into automated production lines, food processing facilities can achieve a higher level of autonomous operation, marking a substantial move towards intelligence and precision within the industry. Currently, intelligent robots are undeniably a cornerstone for modern food processing production lines (Song *et al*., 2025).

Waste Reduction and Sustainability
AI contributes profoundly to minimising food waste by intelligently sorting edible but misshapen products for further processing instead of disposal. It optimises ingredient usage to reduce excess and recommends recycling or alternative uses for by-products. These AI-driven efforts actively support a sustainable agro-food ecosystem and align with global environmental objectives.

The integration of AI into these critical areas represents a paradigm shift, promising to make food processing more efficient, safer, and sustainable (Mengistu & Ashe, 2024).

Table 1: Early adopters of artificial intelligence in the Nigerian food processing industry

S/N	Organisation	Technologies implemented	Outcome	Source
1.	Dangote Industries	Automated and smart system for ordering. Robotic arms for packaging. AI-powered quality control systems	Application available on both Android and iOS platforms, enhanced the ordering channel. Increased export capacity Precision and waste reduction in operation.	Dangote Sustainability Report, 2023. https://www.dangote.com/dangote-group-deploys-advanced-technology-in-companies/
2.	Guinness Nigeria	Internet of Things (IoT) and Predictive Maintenance Sensors installed on boilers and bottling lines. Predictive Analytics by Microsoft Azure.	30% reduction in unplanned downtime, $1.2 million annual savings on maintenance. Consistent product quality.	Balogun, 2025.
3.	Nigerian Breweries	IoT (Internet of Things) Platform deployed to the breweries. Interactive Dashboards ufor Meetings across breweries.	Cost savings and energy efficiency in PET bottle production. Improved efficiency	2024-Rights-Issue-Shareholders-and-Investors-Engagement-Session-Presentation
4.	Nestle Foods	AI-Driven Demand Forecasting using ML algorithms to analyse market trends and social media sentiment to predict sales. Robotic arms for precision tasks in packaging and assembly. Autonomous Guided Vehicles (AGVs) for transporting materials and goods within factories. Blockchain Traceability	Increased output and reduction in human error across the production lines. Streamlined internal logistics. Real-time tracking of raw materials from farms to factories. 25 % improvement in inventory turnover, 30 % reduction in stockouts.	Nestlé Annual Report 2024 https://www.nestleyouthentrepreneurship.com/artificial-intelligence-and-data-science-support-innovation
5	Kike AI	App using advanced algorithms and data analytics. Supply chain and inventory management.	Increased demand and improved operational efficiency.	MSME Africa,2025 https://msmeafricaonline.com/kike-ai-launches-to-transform-nigerias-kitchen-economy-and-create-one-million-job/
6	ReelFruit	E-Commerce Integration	200 % Revenue growth	PwC, 2025
7	Abebi Foods	Supply chain Management	Enhanced operational efficiency	Abiodun, 2025

Artificial intelligence in the Nigerian setting

In the Nigerian context, Artificial Intelligence (AI) presents a unique blend of significant opportunities and distinct challenges. The country is increasingly recognising AI's potential to drive economic growth, enhance public services, and position itself as a digital leader in Africa. Nigeria's Artificial Intelligence (AI) industry is experiencing significant growth, fueled by a burgeoning population of tech-savvy young people and a surge of innovative startups (Balogun, 2025).

The Nigerian government is also actively fostering innovation and capacity-building within the AI sector through various strategic initiatives. Notably, these include the Nigeria Artificial Intelligence Research Scheme (NAIRS) and the National Centre for Artificial Intelligence and Robotics (NCAIR), both of which offer crucial funding, infrastructure, and technical support for AI-driven projects. Most recently, the government launched its comprehensive National AI Strategy. This strategy articulates a clear vision for harnessing AI to boost economic competitiveness, advance social inclusion, and solidify Nigeria's position as a leader in technological innovation (PwC, 2025).

Within the food processing industry, some early adopters such as Dangote Industries, Nestlé Nigeria, Guinness Nigeria, Nigerian Breweries and SMEs (Kike AI, ReelFruit and Abeebi Foods) demonstrate the transformative impact of AI technologies and emphasised that strategic investments in robotics, Internet of Things (IoT)-enabled predictive maintenance, and digital supply chain platforms can greatly enhance productivity (Table 1).

Challenges in Implementing AI in the Nigerian Food Processing Industry

Implementing Artificial Intelligence (AI) within the Nigerian food processing sector, particularly in presents several significant challenges despite the huge promising trajectory of AI. Although, research has indicated that artificial intelligence applications, such as machine learning models for weather prediction and drone technology for crop monitoring, have had a favorable impact on agricultural practices in Nigeria, the food processing industry still faces considerable hurdles in the utilisation (Onyezere *et al*., 2024). The widespread use of AI in Nigeria is hampered by a number of issues:

High Initial Investment: Integrating AI necessitates substantial capital outlay for acquiring specialised equipment, sensors, software, and for comprehensive workforce training.

This considerable initial investment can be prohibitive for many small and medium-sised enterprises (SMEs). Food processing remain largely unautomated particularly among the small scale processors due to paucity of funding (Iqbal, 2024). Recently (June 2025), the Nigeria Artificial Intelligence Research Scheme awarded the sum of Five Million Naira (about $3,000) each to startups and researchers, none of which invested in food processing (Nwamekwe *et al*., 2024).

Internet Connectivity Deficiencies

Dependable internet access is fundamental for AI applications. However, Nigeria, like many African nations, struggles with poor internet penetration, particularly in rural areas. As of 2025, just over 40% of Nigerians were online, with a notable disparity between urban and rural access (Internet World Stats, 2023). This digital divide is exacerbated by the high cost of internet services and frequent outages, which collectively restrict the widespread adoption of AI-driven solutions (Adeniran & Ayo, 2023).

Unreliable Power Supply

AI systems demand a consistent and stable power source to operate efficiently. Unfortunately, Nigeria continues to grapple with persistent blackouts and insufficient electricity coverage. In 2023, only approximately 55% of Nigerians had access to electricity, with rural regions being the most affected (World Bank, 2023). This unreliable power infrastructure presents a substantial impediment to deploying AI systems nationwide.

Technical Expertise Shortage: The successful operation and maintenance of AI systems demand a workforce proficient in areas such as data science, AI specialisation, and advanced machine operation. But, there is currently a noticeable scarcity of these skilled professionals in Nigeria, particularly in the agro-processing sector (Onomu & Aliber, 2024).

Data Quality and Availability: The efficacy of AI systems is directly tied to the quality and relevance of the data they process. In agro-food processing, issues like data inconsistency, fragmentation, or outright unavailability can severely compromise AI's effectiveness and reliability (Sulaiman *et al*., 2025).

Cybersecurity Risks: AI-powered food processing systems, by their nature, are interconnected through networks, which increases their vulnerability to cyber-attacks. Such breaches could lead to significant production disruptions or the theft of sensitive operational data. Data privacy is a significant concern in Nigeria, as many AI systems rely on extensive datasets that may contain sensitive personal information (Ghasemlou,*et al*.,2025; Balogun, 2025).

Regulatory and Ethical Complexities

The deployment of AI for critical decision-making in areas such as food safety and quality control presents significant regulatory and ethical challenges. Paramount among these are concerns surrounding accountability, particularly in the event of system malfunction or error, which necessitate careful consideration and the establishment of clear guidelines (Adanyin, 2024; Sharma *et al*., 2024).

In Nigeria, a notable absence of robust legal and ethical frameworks to govern AI research and implementation currently exists (Balogun, 2025). Ensuring the ethical utilisation of AI also requires addressing algorithmic bias, which can lead to unfair outcomes and exacerbate existing socioeconomic disparities. Furthermore, the automation of certain roles through AI implementation could result in substantial job displacement, particularly in sectors heavily reliant on repetitive operations (Adediran *et al*., 2024).

Unleashing AI's Potential: A Call for Data-Driven Skill Development

To fully realise the transformative potential of Artificial Intelligence (AI) in Nigeria, a concerted national effort towards comprehensive digitisation across all sectors is paramount. This strategic digitisation will be instrumental in generating the extensive and diverse datasets necessary to fuel AI-driven innovation and development within the country (Okorieocha & Ugwunali, 2025).

Addressing the existing skill gap in advanced data science and AI expertise is critical for Nigeria to effectively harness these opportunities. Programs like the Federal Ministry of Communication and Digital Economy's 3 Million Technical Talent (3MTT) initiative, Microsoft's AI Skill Navigator, and other similar training schemes are vital for cultivating the next generation of AI professionals. These initiatives are essential to bridge the current talent vacuum and equip Nigerians with the specialised skills required for an AI-driven economy (Ogunbodede & Atchrim, 2025).

Given Nigeria's significant youth demographic, both public and private sector enterprises have a unique and unprecedented opportunity to fully leverage the advantages that AI offers. By prioritising investment in AI education and skill development, these organisations can empower their workforce, drive substantial technological progress, and unlock AI's full potential to foster economic growth and solve pressing national challenges (Daddie *et al*., 2025).

Conclusion

Artificial Intelligence can transform Nigeria's food processing industry by boosting efficiency, productivity, quality, and safety. Nigeria in particular, stands at a pivotal juncture in its technological advancement, with AI presenting both profound opportunities and significant implementation challenges. However, the nation grapples with critical deficiencies in its digital infrastructure, a pronounced shortage of specialised technical expertise, and the imperative need for robust ethical and regulatory frameworks to govern AI adoption. A strategic imperative to resolve the challenges involves substantial investment in upgrading digital infrastructure, which includes expanding high-speed broadband access across urban and rural areas and developing state-of-the-art data centers capable of supporting AI-intensive workloads. Such foundational improvements are crucial for reliable AI deployment and scalability. Concurrently, bridging the pervasive AI skills gap demands a comprehensive national strategy. Furthermore, the establishment of comprehensive legal and ethical frameworks, such as the recently introduced Nigerian Ethical AI Framework (NEAIF), is indispensable to ensure the

transparent, accountable, and responsible development and deployment of AI systems, safeguarding against biases and promoting fairness.

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