TRANSFORMING FOOD PROCESSING THROUGH ARTIFICIAL INTELLIGENCE: A STUDY ON PRACTICAL APPLICATIONS AND IMPACTS

Abstract

Artificial Intelligence (AI) has revolutionised the food processing sector by enabling unprecedented levels of automation, efficiency, and safety across the supply chain. These technologies are transforming traditional practices into smart, data-driven operations. This paper looked into different practices of AI in food processing and delivery, including quality inspection, hygiene monitoring, temperature control, fraud detection, and supply chain management. The adoption of AI not only enhanced operational efficiency and cost-effectiveness but also ensured compliance with health and safety standards. This study concluded that AI was not only a new trend but also a strategic necessity in modern food processing.

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Introduction

The application of artificial intelligence (AI) to the food processing sector marks a significant leap toward smart manufacturing and intelligent delivery systems. AI tools such as machine learning, deep learning, and computer vision are redefining the boundaries of food production, logistics, and consumer interaction. As global demand for food grows and supply chains become more complex, the adoption of AI enables companies to improve efficiency, ensure food safety, and respond rapidly to market trends. The application of AI in the food processing sector has been growing for years due to various reasons, such as quality control, food sorting, prediction of parameters, and food safety (Nidhi Rajesh Mavani et al., 2021). Now many food business entrepreneurs have applied AI in different fields such as supply chain management, food storing, production development, food quality improvement, and proper industrial hygiene. This paper investigates the integration of AI in different areas of the food

industries, highlighting its impact on operational efficiency and turnover.

The role of AI in Food Delivery and Customer Engagement

1.1 Enhanced customer interaction

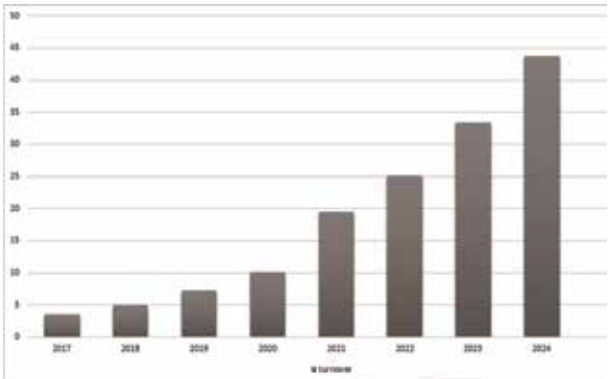
AI-powered chatbots are designed to imitate human conversation and play a crucial role in modern food ordering platforms. They apply natural language processing methodology to comprehend and read user input and produce responses in accordance with pre-programmed rules or machine learning algorithms. These bots provide real-time assistance, allowing users to place orders, track deliveries, and receive personalised recommendations. It enables quick responses and the ability to promptly provide relevant details without human intervention. It benefits businesses by managing multiple customer enquiries and reducing the need for extra staff. They also support internal operations like answering employees' queries and assisting with various tasks. By leveraging historical customer data, chatbots enhance user experience and enable platforms to scale customer service without a proportional increase in manpower.

The famous food business like Starbucks uses chatbots to make ordering more convenient. It introduced an AI-operated barista support designed to simplify order processing, cut wait times, check loyalty rewards and stay updated on promotions. By implementing AI, Starbucks aims to improve order accuracy, minimise order wait times, free up human staff to focus on customer interaction and coffee preparation, and enhance the overall customer dealings. Panda Express has a chatbot on Messenger that helps customers find menu items and place orders with a smooth and hassle-free process. It utilises SYNQ3's AI voice ordering technology to place orders using voice commands, streamlining the ordering process and reducing wait times. Additionally, Panda Express has a mobile app that offers mobile ordering, Panda Rewards and a store locator. Burger king's digital assistant helps customers place orders, track orders and resolve issues. It provides automated replies to generalised questions, and customers can speak with a human agent when needed. Domino's Dom chatbot, accessible through Facebook Messenger, Amazon Alexa and Google Assistant, enables customers to place orders, track deliveries and access previous orders. The easy order feature allows customers to quickly reorder their favourite dishes. Swiggy customises discounts and offers for its customers using AI. To provide a discount the platform considers customers' order history and other relevant data. It provides more targeted offers, which has increased the customer happiness.

The following graph represents the turnover of Swiggy before and after the implementation of AI technology in their food business.

1.1.1

Swiggy annual turnover from 2017 to 2024



(Source: Swiggy annual reports)

Swiggy started exploring AI in their food system around 2019-20. But significant advancements were made during 2022-23. The following graph showed a turnover from 2017 to 2024. The turnover was low in 2017 and 2018. From the year 2019 onwards, there was a noticeable increase each year. After using AI technology, the turnover jumps significantly from 2022 to 2024, with the highest value in 2024.

1.2 Fraud detection in delivery apps

The growing prevalence of digital transactions and complex financial systems has given rise to increasingly sophisticated fraudulent activities. This poses a significant threat to customers and harms the reputation of genuine food operators. Machine learning is a subset of AI that focuses

on developing algorithms that allow computers to learn from and make predictions based on data (Oluwabusayo Bello & Komolafe Olufemi, 2024). This model can identify suspicious activity such as fake orders or payment fraud, thus protecting both businesses and customers.

Swiggy, India's leading food delivery platform, uses SHIELD's fraud monitoring solutions to enhance its fraud detection capabilities. Sensfrx offers a comprehensive fraud detection and prevention solution, using AI powered anomaly detection to safeguard consumers and food delivery businesses.

Role of AI in Food Processing and Quality Control

2.1 Smart Food Processing and Automation

AI-driven robotics automate key processing steps such as sorting, slicing, mixing, and packaging with high precision. Robotics is a branch of automation that is involved in the process of controlling equipment to perform operations with little or no human interference. The use of these technologies in the food industry has been on the rise as a result of the following factors: ensuring consistency, reducing human error, minimising labour dependency, and making operations faster and safer.

The famous businesses like JBS employ AI-driven robotics to automate complex meat-cutting processes, ensuring consistent portion sizes and minimising product loss. Beyond Meat leverages AI and machine learning to refine the flavour and texture of plant-based meat alternatives.

2.2 AI-Powered Quality Inspection

Quality inspection is a planned and organised process in which the state of the product is assessed by examination, measurement, testing, gauging or comparison to determine if it conforms to the desired specification (Sarvesh Sundaram & Abe Zeid, 2023). The AI-orientated vision systems powered by deep learning analyse food products for defects such as discolouration, contamination, or deformities. It identifies differences between features of the product undergoing inspection and the desired features. These tools continuously learn, increasing their accuracy over time and ensuring that only high-quality products reach consumers.

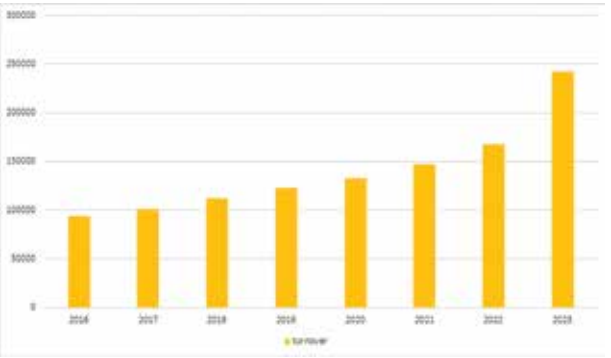
Tyson food implements machine vision to identify signs of spoilage in meat products more accurately than human inspectors. PepsiCo leverages AI in potato chip production to sort out defective chips based on colour, shape and texture. Nestle utilises AI-powered visual inspection systems in chocolate and coffee factories to detect defects and ensure high-quality standards. Their AI-based computer vision systems inspect food products on production lines, detecting issues like discolouration, size anomalies or foreign materials.

Nestle began its digital transformation journey in 2018. In 2021, it implemented an AI platform which became widespread in 2023.

The following graph represents Nestle turnover before and after the implementation of AI technology in their business.

2.2.1

Nestle turnover from 2016 to 2023



(*Source: Nestle Annual reports*)

The turnover shows a generally increasing trend over the years, with a significant jump in 2023. From 2016 to 2020, turnover was relatively stable with minor fluctuations. A slight increase is seen from 2020 to 2022. But with the widespread application of AI technology in their business, a notable spike in turnover occurs in 2023.

Role of AI in Enhancing Safety and Hygiene Standards

3.1 AI for Hygiene Monitoring

The increasing customer knowledge and

demand for transparency are putting more pressure on food operators to meet the highest safety standards. AI-equipped surveillance systems monitor food preparation areas to ensure compliance with hygiene protocols. Infractions such as improper glove use or insufficient handwashing are automatically detected, prompting corrective action to maintain food safety standards.

Tyson Foods implemented automated cleaning systems for maintaining hygiene and reducing water consumption by 2.8 million gallons annually. It showcases their commitment to sustainability and efficient operations.

3.2 Temperature Monitoring

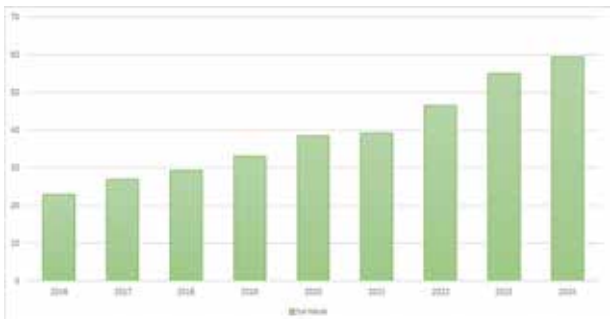
AI-powered sensors track food temperature throughout the processing and delivery phases. When temperatures deviate from safe thresholds, alerts are issued in real time, preventing spoilage and ensuring compliance with safety regulations.

PepsiCo used AI-driven temperature control systems to monitor and adjust temperature, ensuring product quality and safety. Hindustan Unilever also follows these technologies to track and maintain optimal temperature during transportation and storage. Amul utilised industry 4.0 technologies in their milk processing plants. Amul used sensors to monitor temperature, pressure and humidity systems to ensure safety and quality in their dairy products processing and storage (Gyanesh Sinha & Sumit Mishra, 2023).

The following graph represents Amul turnover before and after the implementation of AI technology in their business.

3.2.1

Amul turnover from 2016 to 2024



(Source: Amul annual reports)

Amul turnover has been increasing steadily from 2016 to 2024. At the end of 2021, the organisation implemented AI technologies in different stages, such as milk procurement, milk processing and packaging and distribution, to monitor temperature, pressure and humidity systems. With the integration of AI technology across various business functions, Amul experienced a notable increase in turnover from 2022.

Role of AI in Supply Chain Management

AI enables end-to-end visibility across the supply chain by monitoring inventory levels, supplier reliability, route efficiency, and storage conditions. Predictive analytics allows businesses to forecast demand accurately, manage perishable inventories efficiently, and minimise wastage. In the face of disruptions, AI models can suggest alternate routes or sourcing strategies, ensuring supply continuity. The most prevalent AI technique is ANNs which can apply to several categories of problems, including pattern classification, approximation, optimisation, clustering, function, prediction, retrieval by content and process control (Reza Toorajipour et al., 2021). The implementation of AI in supply chain management comprises various areas such as demand forecasting, procurement, inventory management, customer relationship management, transportation networks, resilience and risk.

Kraft Heinz is developing a system that creates a digital version of its supply chain, allowing it to make automatic decisions about things like product movement and scheduling, helping it respond quickly to changes in consumer preferences. The business is also piloting a generative AI-enabled product known as Plant Chat that collects real-time observations across the supply chain from employees making key business decisions. Britannia industries has also developed the Bhub AW app to optimise its supply chain, simplifying processes and utilising

real-time data to expand its business.

Challenges in adopting AI in the food industry

The adoption of Artificial Intelligence (AI) in food processing holds huge potential for enhancing food safety and quality. However, the food processing sectors, mainly small and medium enterprises, face various challenges that hinder the effective integration of AI technologies into their operational activity.

One of the main barriers is high implementation cost. AI-based systems require large investment in technology, infrastructure, and skilled manpower. Many micro, small and medium food sectors operate on limited budgets, making it difficult to allocate funds for advanced technology implementation. The lack of technical expertise is another major obstacle. The units faced a lack of employees trained in AI, data analytics, and machine learning, which are essential for operating and maintaining AI systems.

Data availability and quality also pose a major problem. AI applications rely on large, accurate datasets for effective performance. However, food businesses may not have well-organised digital records or sufficient data to train AI models.

Conclusion

AI is a transformative force in the food industry, enhancing every stage from production to plate. Its capabilities in automation, quality assurance, hygiene enforcement, and supply chain efficiency ensured that food products are safe, consistent, and delivered in optimal condition. As technologies mature, their integration will continue to elevate standards, streamline operations, increase turn over and promote sustainable practices.

Future Scope

The future scope of this study lies in exploring the role of Artificial intelligence across various stages of food processing, from raw material assessment to packaging and distribution. Further research can focus on developing cost-effective AI tools suitable for small and medium enterprises, enhancing data integration, and improving predictive analytics for food quality and safety. MA

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