Artificial Intelligence (AI) in Food Analysis

Swati Sikarwar[1]*, Dr. Kamla Mahajani[2], Gaurav Dhaked[3] and Deepika Kanwar[4]

[1]Masters Scholar, [2]Assistant Professor, [3]Junior Research Fellow,
Department of Food Science and Nutrition, CCAS, MPUAT, Udaipur, Rajasthan-313001

Corresponding Author
Swati Sikarwar
Email: ssikarwar279@gmail.com

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ABSTRACT

Artificial intelligence (AI) revolutionizes food analysis through the provision of fast, accurate, and non-destructive evaluation of the quality, safety, authenticity, and nutritional content of food products. AI methods such as machine learning, deep learning, computer vision, spectroscopy, biosensors, and internet of things (IoT) make it possible to identify food adulteration, contamination, spoilage, and quality issues in real-time while minimizing manual labor and time of analysis. AI also makes it possible to have personalized nutrition, smart packaging, supply chain optimization, and predictive quality management and thus plays an important role in improving food security and sustainability. This article explores the use of artificial intelligence in food composition and quality analysis, the workflow of AI based food analysis, and the different food types that can be analyzed using this technology including dairy products, fruits and vegetables, cereals, meats, seafood, spices, oils, coffee, tea, and processed foods. The advantages, industrial applications, and some of the challenges posed by AI are also discussed in this article.

INTRODUCTION:

Artificial intelligence (AI) technology is revolutionizing the path from ingredient discovery to tailored nutrition. It demonstrates that the power of data-driven food engineering might dramatically change human health,

sustainability and our food consumption in the future (de Souza, 2026). The global food environment is under pressure by multiple factors: demographic change, climate change, food adulteration, malnutrition, obesity and chronic disease prevalence, all of which need immediate, efficient and flexible solutions. In addition, there is an explosive increase in data availability in relation to food products. Databases of clinical nutrition, food production, consumers' behavior analysis, social networks, wearables and mobile applications all generate food-related data. AI technologies have become a part of food industry to help transform existing technologies and develop innovative products based on them. Current research shows that the use of AI technologies enables rapid ingredient discovery, optimal design of formulation and analysis of biochemical and nutritional big data for identification of novel bioactives and sustainable food sources. This article will analyze strengths, weaknesses and potential of AI technologies implementation into food life cycle (de Souza, 2026).

Artificial Intelligence (AI) is promoting the creation of personalized nutrition, a rapidly growing area that is developing personalized dietary advice according to the genetic composition, microbiome of individuals, metabolism as well as life-style information. With the help of AI-based predictive models utilizing multiomics datasets, it is possible to foresee the reaction of an individual to particular nutrients or diet, thus improving preventative care and disease management (Sangma, 2025).

Nowadays, food security and quality problems caused by the impact of climate change along the way from farm to fork can be better predicted using AI. Moreover, AI facilitates affordable scaling up of the service in fields like supply chain management, customer experience, operational efficiencies and reduction of equipment use. Vision-guided robot, backed by AI, can distinguish objects in a complex environment, perform tasks with great accuracy and prevent errors during food processing, thus maintaining product quality. Modern processing technologies improve nutritional content of food as well as provide affordable and convenient food products, which requires new technologies to address food insecurity and hunger problems. The fast pace of technological advancement due to digitalization and artificial intelligence (AI) raises the question about reconsideration of FSTand E education (İçöz, 2026).

1. AI in Food Composition and Quality Analysis

Artificial intelligence (AI) is changing the way the food industry works through automation of food analysis, providing speed, accuracy and automation that are difficult to achieve using conventional laboratory approaches. AI-based spectroscopic methods have proven useful in detecting adulterations in foods such as watered milk, adulterated spices and artificial colorants in juices with very little preparation work done (Sangma, 2025).

Intelligent nutrition platforms are making decisions easier through the use of AI. Some of these companies include Edamam and Passio, which utilize machine learning, image recognition and recipe analysis technology in order to give the consumers real time nutritional information and diet plans based on user input and food images (Cecchini, 2017).

Computer vision is a technique used to evaluate the physical attributes of foods such as the color, texture, size and shape. This technique is applied in grading and sorting fruits, vegetables, meat and bakery items. Also, smartphones are used to identify foods and assess their nutritional content. Through the incorporation of AI with smart sensors, there is now the real-time monitoring of the quality and safety of food in the supply chain.

Smart sensing systems monitor parameters like temperature, humidity, pH, water activity, oxygen concentration, and gas emissions to identify the spoilage and make shelf-life predictions in packaged food (Sangma, 2025).

Apart from being used in quality monitoring, AI assists the food industry through better demand forecasting, inventory management, and dynamic pricing by leveraging historical sales data and market trends to reduce food wastage. This way, the management of the perishable food can be optimized (Raj, 2024).

The use of AI in precision nutrition is growing through the incorporation of the information on genetics, gut microbiome, dietary pattern, and lifestyle in formulating personalized nutrition guidelines. The AI digital health platform, using machine learning techniques, provides customized meal planning, nutritional advice, and treatment of diseases like obesity, diabetes, and hypertension (Mir *et al*., 2025).

Additionally, the use of AI has been successful in ensuring the safety of food through efficient detection of contaminants. A great deal of accuracy has been witnessed through the combination of machine learning along with sensing technology to detect mycotoxins in products such as coffee, milk, and cereals (Qualmann, 2023).

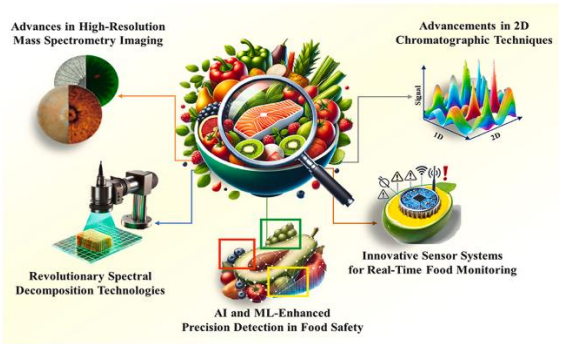

Figure 1: AI in Food Composition and Quality Analysis

2. AI Workflow in Food Analysis

Workflow for AI in food analysis starts with sampling the food product in the form of raw material or any other food product. Further data are acquired with the help of advanced technology tools like spectroscopy, computer vision, imaging systems, biosensors, and internet of things (IoT) sensors. Further, the data is pre-processed before applying any analysis in order to remove the noise and improve the quality and reliability of data. Characteristics called features that describe the data like spectral features, colour, texture, shape, and chemical composition are extracted from the data to create the representative feature vectors. After that, the features are further used for processing with the help of machine learning and deep learning algorithms that learn patterns corresponding to different characteristics related to quality, adulteration, contamination, or freshness. AI makes predictions based on these learned patterns to classify the samples with respect to their predefined quality and safety criteria.

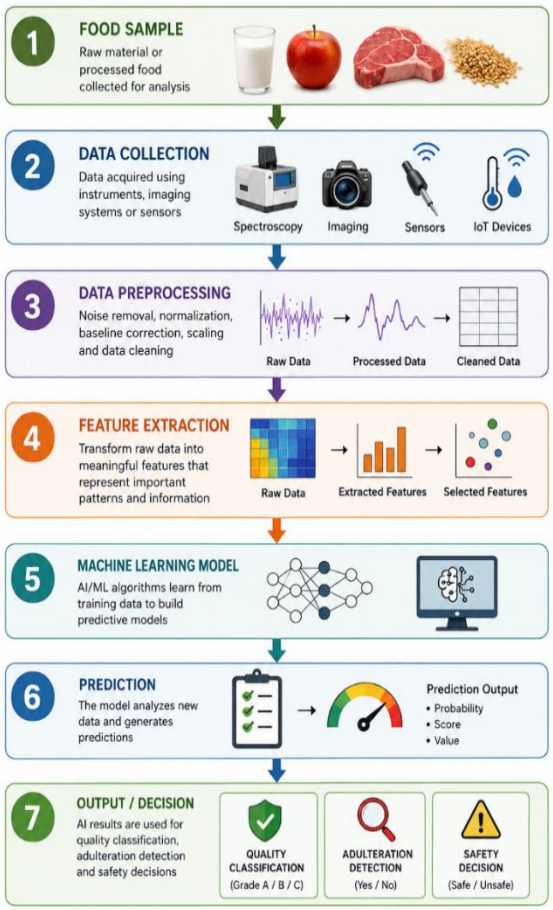

Figure 2: AI Workflow in Food Analysis

3. AI Applications in Different Food Categories

Artificial Intelligence (AI) are being increasingly adopted in many food sectors to quickly assess the quality, safety, authenticity, and nutritional attributes of food products. Using ML, DL, and CV in conjunction with imaging, spectroscopy, biosensors, and sensors based on the Internet of Things (IoT), AI allows for the precise detection of adulteration, contamination, quality degradation, and other anomalies.

Table 1: AI Applications Across Different Food Categories

S. No.	Food Category	AI Technologies	Major Applications
1.	**Milk and dairy**	Machine Learning (ML), Deep Learning (DL), Fourier Transform Infrared Spectroscopy (FTIR), Near-Infrared Spectroscopy (NIR), Raman Spectroscopy	Adulteration detection, quality grading, freshness assessment
2.	**Fruits and vegetables**	Computer Vision (CV), Convolutional Neural Networks (CNN), Hyperspectral Imaging (HSI)	Ripeness prediction, grading, disease detection, shelf-life estimation
3.	**Meat and poultry**	Computer Vision (CV), Electronic Nose (E-nose), Machine Learning (ML)	Freshness detection, adulteration identification, microbial assessment
4.	**Fish and seafood**	Deep Learning (DL), Electronic Nose (E-nose), Hyperspectral Imaging (HSI)	Spoilage monitoring, species authentication, shelf-life prediction
5.	**Cereals and grains**	Machine Learning (ML), Digital Image Analysis, Spectroscopic Techniques	Mycotoxin detection, grain grading, moisture analysis
6.	**Spices and condiments**	Fourier Transform Infrared Spectroscopy (FTIR), Raman Spectroscopy, Hyperspectral Imaging (HSI)	Adulterant detection, authenticity verification
7.	**Edible oils and fats**	Machine Learning (ML), Fourier Transform Infrared Spectroscopy (FTIR), Gas Chromatography (GC), Nuclear Magnetic Resonance (NMR) Spectroscopy	Purity analysis, rancidity prediction, authenticity assessment
8.	**Coffee and tea**	Electronic Nose (E-nose), Computer Vision (CV), Machine Learning (ML)	Origin authentication, roasting quality, flavour prediction
9.	**Honey**	Spectroscopic Techniques, Machine Learning (ML), Raman Spectroscopy	Fraud detection, botanical origin classification
10.	**Processed foods**	Artificial Intelligence (AI)-enabled Sensors, Internet of Things (IoT), Computer Vision (CV)	Packaging inspection, quality control, shelf-life prediction

4. Benefits and Industry Impact

- **Precision and Accuracy:** AI-based systems help increase the accuracy and precision of detection methods.
- **Speed and Automation:** Automatic decision-making greatly decreases analysis time and minimizes human error.
- **Cost Effectiveness:** With a decreased need for reagents and laboratory equipment along with specialists, AI helps reduce costs.
- **Scalability:** Such tools can be used in different organizations and for various types of food, which means that they can be implemented by large manufacturers as well as small ones (Sangma, 2025).

5. Challenges of AI in the Food Industry

- Individuals often misinterpret AI as a mechanism to replace humans, resulting in fear because of ignorance about AI.
- Organizations may not know how AI models can help them reach their goals.
- For the starting stage, finding the right data and feeding that data to AI is one of the biggest problems.

- The implementation of AI models in the organization needs extensive training of employees.
- AI models are costly; therefore, they cannot be afforded by many small-scale industries (Jain, 2021).

CONCLUSION

Artificial Intelligence represents a breakthrough innovation in the field of food analysis, providing quick, precise, and non-destructive methods for food assessment concerning quality, safety, authenticity, and composition. With the combination of machine learning, deep learning, computer vision, spectroscopy, biosensors, and IoT systems, AI makes possible the efficient identification of food fraud, contamination, deterioration, and quality issues in various types of food items. The implementation of AI technologies is associated with high costs and is further constrained by the limited availability of high-quality datasets, inadequate computational infrastructure, and a shortage of skilled personnel. With the continued development of artificial intelligence, its combination with contemporary analytics techniques will enhance their precision, efficiency, and performance. Artificial Intelligence becomes a crucial instrument for ensuring food quality and public health in a rapidly developing world.

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