

# Review: The Role of Artificial Intelligence in Food Science and Human Nutrition

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### ABSTRACT

**Background:** Artificial intelligence (AI) technologies are becoming indispensable as the focus of nutrition research broadens to examine the complex relationship between food and health in both an individual and a community setting. AI is also used to track down and provide solutions for food processing, nutritional assessment, clinical and customized nutrition, and the prediction and treatment of diseases like obesity, diabetes, cancer, and cardiovascular diseases. Investigating and evaluating the various uses and functions of AI in food science and nutrition, as well as comprehending its possible future effects, are the goals of this review.

**Methods:** I used PubMed, Scopus, Web of Science, Google Scholar and Other source for my search.

**Results:** The results show that artificial intelligence is changing food supply chain, improve decision-making and operational effectiveness. AI in food processing holds promise for raising agricultural output, enhancing quality control, and lessening environmental impact. AI has become a vital tool by improving our ability to evaluate diets, create personalized nutrition regimens, and treat complicated medical issues. The precision of nutritional monitoring is being revolutionized by technologies such as wearables, chatbots, and machine learning models, which make it simpler than ever to offer customized solutions for both individuals and communities. These developments are helping to prevent diseases linked to diet and promote better eating practices.

**Recommendation:** Utilization of AI in food science and nutrition will have more positive impact in countries like Ethiopia as it improve quality and quantity of food processing to meet high population demand.

**Keywords:** Food Science, Nutrition, Artificial Intelligence, Food Safety.

### Introduction

#### Definitions of Artificial Intelligence (AI)

The term “Artificial” implies made or produced by human beings rather than occurring naturally, especially as a copy of something natural while “Intelligence” refers to the ability to acquire and apply knowledge and skills.

The concept of Artificial Intelligence is not as modern as we think it is. This traces back to as early as 1950 when Alan Turing invented the Turing test [1]. Over the past decades, different definitions of AI have emerged [2]. Defining AI is challenging because of the complexity of the subject it addresses [3]. It is not surprising that AI is so difficult to define clearly [4]. It is,

after all, an imitation or simulation of something we do not yet fully understand ourselves human intelligence [5]. AI Agents can guide us through crafting Specific, Measurable, Achievable, Relevant, and Time-bound goals (Vinuesa et al., 2020).

Several attempts to define AI have been made, and the definitions have been criticized, failing to achieve agreement [6]. Intelligence is the ability to learn, understand, and use knowledge to solve problems and make decisions. It’s a general mental ability that integrates cognitive functions like memory, attention, language, and planning [7,8]. The word “intelligence” comes from the Latin word *intelligential*, which means “the action or faculty of understanding”.

Artificial intelligence (AI) has many roles in food science and nutrition. Food is necessary, and the world’s population has

grown over time [9]. The population of the globe is predicted to reach 10 billion people by 2050, with 70% of people living in cities [10]. In 2025, Ethiopia is expected to rank 10th in the world for population with total of 133,859,677 as of January. To accommodate the growing population, an extra 70% of food is required. 70% of all freshwater used on Earth is used for agriculture [10]. Food integrity is, in fact, a complicated and multifaceted problem, and conventional techniques for ensuring food safety and quality depend on manual testing and inspection, which may be laborious and prone to human mistake [11].

### Back Ground Rational of the AI Study

The demand for food is expected to increase from 59% to 98% by 2050 due to the world's growing population [12]. Our daily diets are indirectly shaped by the food processing sector, which transforms farmland crops into the delectable dishes we enjoy. In order to prolong the shelf life of food, it uses techniques such as drying, freezing, pickling, and irradiation. Common examples of processed foods include baked goods, pet food, cereals, chips, almonds, candies, baked goods, baby food, and ready-to-eat meals. Better quality control is one of the main advantages of AI in the food sector. The technique has a high degree of accuracy in identifying and detecting flaws in food goods.

In order to identify problems like contamination, spoiling, and other quality issues, artificial intelligence (AI) systems can examine data from sensors and cameras [13]. Artificial intelligence (AI) has the ability to improve food safety protocols, optimize production processes, increase quality control, lower waste and energy consumption, and simplify supply chain management [14].

Utilizing artificial intelligence's (AI) capabilities to enhance food safety and quality initiatives in the food sector is necessary to address the challenges in AI-enabled food quality management. The food industry needs to employ artificial intelligence (AI) to improve customer happiness, streamline supply chain operations, reduce batch sizes, and find new, cost-effective ways to connect with and serve customers [15].

One of the primary objectives of this business is to establish reliable, standard techniques for product quality control [16]. Interestingly, nowadays, processed foods account for 25% to 60% of many people's daily energy intake worldwide. With the demand for processed foods increasing, artificial intelligence (AI) offers a great solution for streamlining food processing and boosting innovation across the sector.

### The Objective of the Seminar:

#### General Objectives

- This seminar paper is reviewed to address the current role of AI in food science and nutrition while it helps for readers to gain information on the relevance of AI in feature food industry.

#### Specific Objective

- To address common AI involved in food science and nutrition sector development
- To address key importance, strength and limitation of AI technology in food science and nutrition.

### Methodology of the Study

This study was conducted by reviewing and synthesizing different recent and subject based scientific research journal, proceeding, books other web based material to address the role of current artificial intelligence (AI) in food science and nutrition sectors.

### Literature Review

#### Importance of AI in Crop Production

Artificial intelligence (AI) is a set of technologies that can help improve farming processes Predicting crop yields and spot possible hazards, AI algorithms examine past data, weather trends, and soil conditions [17]. By evaluating information from sensors, satellite imagery, and climate models, AI can identify illnesses and pest infestations early.

As a result, farmers might be able to use fewer chemical pesticides [18]. AI also help to analyze soil properties including moisture content, nutrition levels, and pathogens using data from sensors, agricultural equipment, drones, and satellites [19]. AI can help farmers optimize resource usage like water and fertilizers [20]. AI can recognize and manage weeds using computer vision, robots, and drones [21]. By evaluating past and present data to predict weather patterns and climatic consequences, artificial intelligence (AI) in agriculture also enables farmers to adapt to climate change [22]. AI in automated harvesting offers skills related to fleet coordination, robotic motion control, and computer vision that seek to mimic and even improve the effectiveness of human fruit pickers using sensors and algorithms [17]. Automation in food preparation and delivery powered by AI improves efficiency and streamlines procedures.

AI also improves food safety by monitoring data to identify possible risks and guarantee adherence to safety regulations, and it makes individualized marketing methods possible to increase sales and consumer loyalty [23].

In comparison to piloted aerial vehicles, unmanned aerial vehicles are a new technology that can offer a better alternative for acquiring remote data in less time, at a cheaper cost, and with greater safety. Chat bots driven by artificial intelligence and machine learning techniques have made it possible for us to comprehend natural language and communicate with consumers in a more tailored manner [17]. Their primary functions include retail, travel, media, and agricultural. They have utilized this facility to help farmers get the answers to their unanswered problems, as well as to offer them counsel and other recommendations [17].

#### The Importance of AI in Postharvest Processing

Automated packaging systems are useful for a variety of industries, such as food manufacturing, e-commerce, and wholesale distribution. Assign robots to product placement, picking, and sealing. They can also handle delicate or delicate foods with precision, minimizing product damage. By doing this, you reduce errors, expedite the process, and ensure consistent package quality [24]. Any contaminated products are removed from the production line after defects are discovered and products are categorized by size, shape, or color. Use it to maintain product quality and safety standards [25]. By lowering manual labor and lowering the possibility of product contamination, automation food technology assist businesses in

moving ingredients, raw materials, and completed goods around the production area. Additionally, they automate container loading and unloading, which aids in supply chain optimization [26]. Robots are used for a variety of food assembling and processing jobs. In meat processing, for instance, they carry out accurate cutting, trimming, and deboning procedures, increasing uniformity and decreasing waste. For consistency and efficiency, bakeries utilize robots to automate the handling, filling, and decorating of dough [27]. By automating the cleaning and sanitation process using specialized cleaning attachments, robots can lower the danger of cross-contamination. AI can help manufacturing surfaces, conveyor belts, and equipment effectively while adhering to strict food safety regulations [28]. Large datasets may be analyzed by AI systems to forecast food safety, quality, and shelf life [13]. AI is able to deliver real-time data on inventory levels, demand predictions, and logistics. By doing this, food waste may be decreased and timely product delivery can be guaranteed [29].

### **Importance of AI Technology Food Production and Processing**

Artificial intelligence (AI) based solutions serve to increase productivity across the board and handle the difficulties that different industries, including the agricultural sector, encounter, such as crop yield, irrigation, soil content sensing, crop monitoring, weeding, and crop establishment [30]. AI in the food industry utilizes technologies like data analytics and machine learning to enhance food production, precision agriculture, quality control, personalized nutrition, supply chain management, and customer experience [14]. Through increased production efficiency, improved quality control, waste reduction, tailored nutrition, and supply chain transparency, artificial intelligence is transforming the food sector. For food manufacturers and other supply chain participants to remain competitive, satisfy changing customer needs, and build a safer, more sustainable food environment, they must use AI technologies as they develop [31]. The food business can lead the way toward a future that is more consumer-focused, transparent, and efficient by utilizing artificial intelligence [32]. AI creates new opportunities for product innovation and customized nutrition.

Large databases of customer information, such as dietary preferences, allergies, and medical problems, can be analyzed by machine learning algorithms to produce customized product offerings and personalized food suggestions. Chatbots and virtual assistants driven by AI can help customers make well-informed nutritional decisions based on their unique requirements. Additionally, by utilizing data-driven insights on customer trends, flavor preferences, and ingredient combinations, artificial intelligence (AI) helps food makers create novel and inventive goods [33]. In order to ensure accuracy, efficiency, and the development of consumer trust, artificial intelligence (AI) is revolutionizing food labeling claims, including nutrition, health, and other promotional claims on the pack.

### **The Importance of AI in Food Value Chain System**

This paper explores the various uses of AI in the subject of food integrity, providing a thorough analysis of current advancements and their consequences, in acknowledgment of the potential for AI and ML to completely transform food integrity procedures. Every application, from using computer vision to inspect, sort,

and grade food to predicting patterns of pathogenic microbial contamination, is a step closer to a safer and more dependable food supply chain [11].

Clinicians can use AI to make better decisions on the dietary needs of their patients. Patients may track their food intake and choose healthier options with the aid of AI-powered gadgets and apps [6]. AI improves the detection of food contaminants by decreasing human error and increasing accuracy. Proactive risk mitigation is made possible by machine learning, which forecasts contamination patterns. AI's real-time monitoring improves consumer safety by quickly identifying pollutants [13]. Food processing contributes significantly to a more sustainable environment in addition to ensuring that food is safe to consume. By keeping seasonal produce fresh and accessible all year round, it can help cut down on food waste. Additionally, it can assist avoid nutritional shortages by addressing particular dietary requirements, such as those for plant-based or gluten-free items [34]. The removal of dangerous bacteria, particularly those that can cause illness, is another important justification for food processing. Food can be penetrated using methods like irradiation to destroy or stop the growth of dangerous bacteria without leaving any toxic leftovers [35].

In every facility that processes food, quality control is essential, and computer vision can be very helpful in maintaining quality standards and laws. Compared to traditional inspection techniques, they provide a greater degree of accuracy and effectiveness [36]. Using sophisticated image processing and machine learning techniques, computer vision solutions can swiftly and precisely check food products for a range of quality and safety characteristics. This include spotting contamination, looking for flaws in the packaging, and making sure labels adhere to regulations [37]. This is further enhanced by YOLO11's object-tracking features, which allow for real-time label reading of goods as they pass along manufacturing lines. YOLO11 can track and crop the label as each item moves through the camera's field of vision. Optical Character Recognition (OCR) can then be used to read the clipped label. Without interfering with the production process, this procedure guarantees that every product is appropriately branded.

Labeling accuracy may be preserved using real-time tracking and OCR, ensuring regulatory compliance even in hectic settings [38].

### **Importance of AI in Food Safety and Regulation**

AI is developing swiftly and has the potential to completely transform the field of nutrition, particularly clinical nutrition [39]. There are numerous methods that artificial intelligence (AI) can enhance agricultural output, including: Predicting crop yields AI is able to forecast crop yields for a specific season by using information on weather, climate, and other environmental parameters. Farmers can use this to determine when to plant and harvest crops [40]. Artificial intelligence (AI) evaluates data from soil sensors to reveal information about moisture, nutrient content, and pH levels. By using data from sensors that measure soil moisture, such as those made by Delta-T Devices, farmers can improve crop health and productivity by making more educated decisions about fertilization and soil management [41].

AI can assist farmers in making data-driven decisions that will maximize crop yields, save expenses, improve sustainability, increase production, and conserve key resources [42]. AI's core function in nutrition is to provide dietary assessment, with a smaller focus on lifestyle interventions, diet-related diseases, and malnutrition prediction [6]. Artificial intelligence enables farmers to compile vast amounts of data from public and governmental websites, evaluate it all, and offer answers to a variety of unclear problems. It also gives us a more intelligent method of irrigation, which increases farmers' yield [17]. Public health and nutrition are among the industries that are starting to change as a result of the quick development of deep learning and artificial intelligence (AI) technology [43].

Maintaining a nutritious diet is essential for lowering the risk of chronic illnesses like cancer, heart disease, and stroke. Verifying that food items are free of contaminants and satisfy nutritional criteria is a crucial step in the food processing industry's production process [44].

### **Types of AI Used in Food Science and Human Nutrition Machine Learning (ML)**

ML is a branch of AI that deals with algorithms that automatically get better with practice. Mathematical models for decision-making could be produced by ML algorithms. These models are constructed without programming using big collections of training data. The final ten years of the 20th century saw the widespread adoption of machine learning techniques in search engine applications. It is possible to autonomously monitor soil moisture levels using machine learning techniques. Numerous aspects are analyzed by these algorithms, such as soil type, plant kind, and weather data. Farmers can receive real-time information regarding when and how much water to use for their crops because of the algorithm's continuous monitoring of these variables [45]. Food safety, food manufacturing methods, waste minimization, and sales optimization are all being revolutionized by AI and ML. Accurate demand forecasting, inventory control, and supply chain management are made easier in the food business by AI [46]. Food processing at every stage from growing, harvesting, and storing to preparing and consuming must be taken into account in order to ensure food safety and quality [47]. These procedures are frequently labor-intensive, though.

These days, advancements in machine vision can significantly help enterprises and researchers increase the effectiveness of food processing [36]. Machine learning (ML) lends itself as an alternate technique to deal with this type of data because of its qualities that make it appropriate for such analysis. Important nutrition-related issues like obesity, metabolic health, and malnutrition have already seen the application of machine learning [48]. The main conclusions showed AI's function in nutrition is still in its infancy, with a primary focus on dietary evaluation and less on lifestyle treatments, understanding diet-related disorders, and predicting malnutrition [6].

### **Artificial Neural Networks (ANNs)**

An Artificial Neural Network (ANN) is a computational model that mimics the functioning of biological neurons. ANNs are a type of machine learning model that can be used to solve complex environmental systems. They are made up of layers of connected

nodes that process information to produce an output [49]. Applications for artificial neural networks are extremely diverse. These instruments have long been used by researchers worldwide to boost agricultural production, increasing its efficiency and yielding the best-quality goods [50]. ANNs are helpful tools for food safety and quality analyses, including predicting the physical, chemical, functional, and sensory qualities of different food products during processing and distribution, interpreting spectroscopic data, and modeling microbial growth and using that information to predict food safety [50]. It has been proposed that ANNs could be used to classify dyes, control the dyeing process, anticipate color parameters and recipes, and more [51]. Artificial Neural Networks (ANNs) have been increasingly popular in supply chain management development, especially in demand forecasting, which facilitates information access for food [52]. It was discovered that the artificial neural network (ANN) approach dominated the group of studies on nutrient generation and food composition [53].

### **Internet of Things (IoT)**

A network of devices that can communicate and share information with other systems and devices via the internet is known as the Internet of Things (IoT). IoT devices can send and receive data because they are outfitted with sensors, software, and other technologies.

Users can be informed by the data, or an action can be automated [54]. The Internet of Things (IoT) is a technology that increases agricultural productivity and profitability via the use of smart hardware and software. IoT devices gather information on a number of variables, including temperature, humidity, nutrient levels, and soil moisture [55,56]. Food makers can access and utilize real-time food safety data, including temperature, humidity, carbon dioxide, heavy metals, shipping schedules, and storage conditions, with the aid of IoTs [57]. Age, gender, degree of physical activity, and many other characteristics are taken into account when determining the appropriate quantity of nourishment for an individual. Undernutrition would be defined as a person who does not meet these standard nutrient values, while over nutrition would result from excessive consumption, which would then cause a variety of health issues.

Overall, malnutrition will have an impact by shifting a significant portion of the country's GDP to the medical industry. One of the primary factors contributing to maternal, newborn, and infant mortality disorders, among many others, is malnutrition. Information about diet and nutrition can be obtained through the use of artificial intelligence, such as IOT, [58].

### **The Role of Computer Vision in Food Processing**

Computer vision systems process and analyze images or videos in real time using high-resolution cameras and algorithms [59]. Real-time inferencing allows the system to evaluate and understand data as soon as it is collected. This makes it possible for machines to see and understand visual information in a manner similar to that of the human eye, but faster and more precisely. Using techniques like object detection and pattern recognition, computer vision can automatically follow things on a production line, identify defects, and keep an eye on the quality of the final product [60].

Computer vision, for instance, may scan goods on a conveyor belt in real time at a food processing facility, identifying pollutants or minor flaws that human inspectors might overlook. Immediate product analysis lowers production errors, preserves quality control, and assures food safety. Important Uses of Vision AI in the Food Sector We can monitor and extract insights to help optimize various food processing procedures by using computer vision models such as Ultralytics YOLO11 to analyze photos and video footage [16].

**Strength, Challenges and Limitations of AI in Food Science and Nutrition**

Applying Vision AI-driven food processing technology has several benefits, including task automation and enhanced quality control. By analyzing visual indicators such as texture, moisture content, and signs of temperature exposure, vision AI systems can forecast the shelf life of food products. By providing real-time analysis, these solutions help with waste reduction, inventory management optimization, and product preservation [46]. Vision AI-capable robots can automate production and processing tasks, increasing output and reducing labor costs. Due to their ability to visually inspect and manipulate objects, these robots are able to perform repetitive tasks more rapidly, accurately, and reliably than humans [22]. Through continual size, shape, and appearance checks, computer vision may enable consistent product quality by removing batch variance and guaranteeing that objects satisfy standards [47].

Challenges of AI in feature include: AI has the potential to displace human labor, which could result in job losses and changes to

employment prospects. AI is both generating new employment opportunities and displacing existing ones, especially in sectors of the economy that mostly depend on repetitive and regular labor. A World Economic Forum analysis estimates that by 2025, artificial intelligence would have generated 133 million new employment while also displacing 75 million jobs worldwide [61]. Large volumes of data are gathered and analyzed by AI systems, which may cause consumers to worry about their privacy. Companies need to make sure that their AI usage conforms with data protection regulations [62]. If there are any technical problems or system malfunctions, restaurants that rely significantly on AI may experience operational disruptions [63]. The expense of deploying AI may be a hurdle for smaller companies. To deploy and oversee AI systems, qualified experts are required.

Data quality and Complexity of food systems can be a challenge [64]. For optimal performance, computer vision systems frequently require a steady and regulated environment (appropriate lighting, temperature, etc.). It can be challenging to install such systems in food processing facilities because of the different environmental conditions (freezers, cooking areas, storage spaces, etc.) [36]. Maintaining accuracy and performance requires routine hardware maintenance, software upgrades, and calibration. AI systems may malfunction if they are not properly maintained, which could cause delays in production or problems with quality [65]. Sometimes, AI systems misidentify pollutants, which results in wasteful spending or overlooked safety hazards. These mistakes frequently necessitate human oversight, which lowers automation’s overall effectiveness [24].

**Table 1: Results and Finding Summary**

Topic	Author and Year	The name of AI technology used.	Applicability/Service area	Feature importance.
AI tech used in Agriculture	(Konfo et al., 2023), (Mohsan et al., 2023)	Unmanned aerial vehicles (UAVs)	Open field agriculture, forestry, and livestock farming.	The agri-food sector benefits from the use of digital technologies in achieving Sustainable Development Goals.
	(Talaviya et al., 2020), (Somdutt Tripathi, 2024)	Chat bots for farmers eg (LoginEKO’s Advanced Agriculture Chatbot, Farmer. Chat and ChatGPT )	Crop management, Market information Crop selection, Resource optimization, Advisory and Multilingual support	Farmers are able to increase overall productivity, optimize resource allocation, and make well-informed decisions due to this proactive support.
	(Xu et al., 2022),(Kumar et al., 2021),(En, 2018),(Dhanaraju et al., 2022)	Internet of Things (IoT)	Precision agriculture, Pest and disease control, Livestock management, Waste reduction, Remote farm monitoring, Less energy consumption and Forecasting natural hazards	Farmers can make better decisions and enhance almost every part of their operation by employing IoT sensors to gather machine and environmental parameters.
Food processing and safety management	(Dhanaraju et al., 2022), (Onyeaka et al., 2024)	Machine learning (ML)	Inventorymanagement, Cost reduction, Food quality analysis, Food monitoring AI can help the world’s expanding population by ensuring food security and ending hunger.	ML is a new technology that analyzes food detection data and observations to find trends and forecast future occurrences in the food industry.

The role of AI nutrition and diet planning	(Kassem et al., 2025),(Yang et al., 2024)	Chat bots	AI chat bots use natural language dialogue to offer individualized dietary advice. They offer consumers nutritional adjustments, physical activity objectives, and portion size recommendations.	Chatbots can prepare meals based on personal information such as height, weight, age, and health objectives.
	(Sadique Abdallah et al., 2024),(Theodore Armand et al., 2024)	Deep learning (DL)	It finds distinctive features in datasets using artificial neural networks. It aids in forecasting the link between nutrients and humans, which will assist develop customized diet plans.	Deep learning models offer a useful tool for dietary evaluation by assisting in the analysis of food photos.
	(Varshney et al., 2023)	Machine learning (ML)	use data to track food consumption and nutrient composition, determine dietary patterns, and create customized nutrition recommendations.	Play a significant part in nutrition-related issues like malnutrition, obesity, and metabolic health.

**Summary and Conclusion**

A significant advancement in the development of contemporary AI is represented by the creation of machine learning and deep learning algorithms, which have several practical uses in fields such as computer vision, natural language processing (NLP), and automation and recommendation systems. Many facets of the food sector are currently being revolutionized by these technologies. From food omics and customized nutrition to precision farming and maximized food production. AI provides solutions for demand forecasting, quality control, and traceability in the food processing and distribution industry, increasing productivity and cutting waste. AI-powered food safety monitoring and customized nutrition can also completely transform the health of consumers. The main conclusions showed that artificial intelligence’s function in food science and nutrition is still in its infancy, with a primary focus on dietary assessment and less on lifestyle treatments, malnutrition prediction, and understanding diet-related disorders.

**Recommendations**

To guarantee the safety, superior quality, and regulatory compliance of food items, the food business must establish standardized and trustworthy quality control procedures. The industry should also utilizing AI to manage expenses, provide standardized quality control procedures, and encourage health-conscious food manufacturing and distribution methods more than ever.

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