Apollo Journals
Social Sciences and Humanities Inquiry
SSHI
Vol. 01 Issue 03 2026

Article

Analysis of the Advantages and Disadvantages of Artificial Intelligence—The Intelligent Transformation of Contemporary Social Development

Yuhe Gao

Department of Food Science and Engineering, College of Food Science, Northeast Agricultural University, Harbin 150036, China; Email: hh629732@qq.com

Abstract: Artificial intelligence serves as a key driver in the new wave of scientific and technological revolution and industrial transformation; while it is profoundly transforming people's production and daily lives, it is also reshaping the agricultural and food industries. Scholars have conducted extensive research on how to leverage AI to enhance production efficiency in the food processing sector, improve product quality, and develop new products, achieving significant outcomes in this regard. However, most existing studies remain confined to specific aspects or individual cases, lacking a comprehensive analysis of the opportunities and challenges arising from technological advancements from the perspective of the entire industrial chain. This analysis conducts multi-dimensional research covering the four core segments of the food industry chain: cultivation, processing, research and development, and warehousing and distribution. Building upon an analysis of the consensus and common practical challenges identified in the existing literature, an original two-dimensional analytical framework titled "Technology Empowerment—Risk Constraints" is proposed, which systematically integrates the technical characteristics, application scenarios and industrial impact of AI in the food sector. Four types of common practical challenges that have been repeatedly highlighted in previous literature are identified: structural employment shocks, security risks associated with data across the entire supply chain, algorithmic bias stemming from sample imbalance, and the decline in the professional competence of industry practitioners. For each of these challenges, corresponding mitigation measures are proposed within respective chapters, thereby constructing a comprehensive solution framework designed to provide guidance for fostering the sustainable and healthy development of AI technologies within the food industry.

Keywords: Artificial Intelligence, Food Science and Engineering, Strengths and Weaknesses Analysis, Technological Ethics

Received: 6 July 2026
Revised: 18 September 2026
Accepted: 12 October 2026
Published: 28 October 2026

Copyright: © 2026 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

1.1. Research Background

Artificial Intelligence (AI) is one of the key forces behind the present technological revolution and industrial change that is changing the nature of human manufacturing, daily living, and social organization. At present, artificial intelligence technologies such as machine learning, deep learning, and machine vision have penetrated all links of food science and engineering and play an important role in the industry. Many researchers believe that artificial intelligence can effectively solve numerous problems faced by the food industry. The ready-to-eat food industry faces challenges such as labor shortages, slow sorting speeds, and substandard hygiene conditions; however, the application of artificial intelligence is seen as an effective solution to these issues. By integrating AI with the Internet of Things and sensors, the food industry can transition from traditional, fixed automated production lines to adaptive, intelligent manufacturing facilities, thereby driving the overall intelligent transformation of the entire food sector. From a technical standpoint, the integration of artificial intelligence with emerging technologies—such as quantum computing, biotechnology, and the Internet of Things—will drive further breakthroughs, leading to advancements in data processing capabilities and algorithm optimization; on the ethical and social governance front, global AI ethics guidelines will continue to evolve and mature,

and the emphasis on algorithmic explainability and accountability will shape the trajectory of technological progress, making artificial intelligence safer, more trustworthy, and more controllable. In terms of applications, artificial intelligence will penetrate areas such as agriculture, food processing, catering, and health nutrition even deeper, which will create new business models and formats to unlock the potential of growth in the food digital economy; human-machine cooperation will become the future of the development of the food industry. where human creativity and the high efficiency of AI complement one another to drive up the productivity of the food industry as a whole. It is important to focus on the development of a skilled food AI talent pool, creation of relevant legislation and regulations, and promotion of exchange and cooperation among companies and across regions during this time as key strategies to capture opportunities and respond to the new challenges. Artificial intelligence, similar to all other disruptive technologies, has a great deal of benefits and developmental opportunities, but at the same time, it presents a variety of significant risks and challenges; its development has stimulated mass discussion of such problems as the future of work, data safety, ethical concerns, and fairness in society.

As per the latest studies, it is evident that AI-powered technologies are already in use in the agriculture sector, food processing sector, R&D activities and supply chain management and have made certain more specific analyses of specific problems, however, most of the investigations concentrate on the separate elements or facets rather than viewing them as the whole aspect of the risk factors in the food industry. Besides, the best practices of governance available in the available literature are mostly generic principles of governing AI that cannot be directly translated into the peculiarities of the food industry such as the unpredictable and non-uniform availability of raw materials, stringent safety requirements, and a significant number of small producers.

1.2. Research Object

In this paper, the agri-food industrial chain is divided into four core segments: cultivation, processing, research and development, and warehousing and distribution. This division follows the classic “farm-to-fork” logic of the food industry. These four links cover the whole process from raw-material agricultural production, food transformation and product innovation, to storage, logistics and market delivery. Each segment faces unique industry constraints including perishable raw materials, strict food-safety supervision, heterogeneous raw-material quality and a large number of small-scale producers. Risks and benefits of AI application can be transmitted across these links. Compared with classification by technical types or enterprise scales, this four-segment framework can better capture cross-link spill-over effects of AI technology. Therefore, subsequent analysis on advantages, potential risks and governance measures are all organized around these four industrial-chain segments.

1.3. Research Methods

This paper retrieves relevant literature from the Web of Science core collection database. Search keywords include “artificial intelligence”, “food science”, “agri-food supply chain”, “machine learning”, “food processing”, “food safety”. Literature screening criteria were strictly implemented: non-empirical papers relying only on theoretical simulation without real-world food-industry datasets were excluded. The retained literature covers empirical evidence such as enterprise panel data, agricultural field experiments, food production-line test records and supply-chain case studies across four segments: cultivation, processing, R&D, and warehousing-distribution. On this literature basis, this paper sorts out AI practical applications and corresponding risks in the whole agri-food industrial chain, and constructs the two-dimensional “Technology Empowerment—Risk Constraints” analytical framework. Targeted countermeasures are proposed from the perspectives of government, enterprises, educational institutions and farmers, aiming to improve the practical pertinence of research conclusions.

2. The Outstanding Advantages of Applying Artificial Intelligence to Food Science and Engineering

2.1. Enabling Food Processing Automation to Significantly Enhance Production Efficiency

The robots that run automatically on the artificial intelligence concept have a lot of advantages and can be used in the manufacturing sector because they can eliminate the restriction of time that manual labor imposes and do tasks which need a high level of precision or repetitive actions. Food raw materials are perishable and highly heterogeneous. AI-driven robots and machine-vision sorting systems adapt to uneven fruit and vegetable raw materials, reduce manual contact contamination risks required by food hygiene regulations, and cut losses of fresh food in processing links. According to some researchers, technologies of image recognition based on deep learning may be applied to the prepacked food business enabling the round-the-clock and 24/7 implementation of the tasks, such as picking raw materials, eliminating contaminants, and identifying discrepancies, which would allow reducing the shortcomings of the traditional ways, such as low accuracy of classification and unsatisfactory hygiene levels (Huang et al.,

https://doi.org/10.67728/sshi.2026.013

2025). Intelligent production lines that are established through AI technologies can offer the best possible combination of raw materials depending on particular features of the raw materials in the food processing industry (as show in Table 1) and thus decrease the instability in production as a consequence of changing the properties of raw materials and make it possible to produce large volumes and accurately (Song et al., 2025). One of the ongoing trends is that AI-based systems have replaced the previous types of automation and the whole process of food manufacturing, starting with the initial preparation of raw materials and pre-processing of semi-finished products, up to the end-stage packaging of the product (Ayoub, 2026). Such a strategy will assist in eliminating the manual error, operating cost-saving, optimizing processing time, and improving the efficiency of production. At the micro-management level, Ding Mengqi and Gao Qijie conducted an empirical study involving the panel data of Chinese A-share listed agricultural companies and found that artificial intelligence had a unique phenomenon of the agricultural efficiency multiplier effect. It implies an enhanced use of human resources, an increment in the investment in research and development, and a decrease in the operating costs of the company that result in a considerable growth in total factor productivity of agricultural enterprises; the result has been verified by instrumental variable methods and several other approaches to analysis (Ding & Gao, 2025). Wang Yongqin and Liu Fuxing stated that the implementation of artificial intelligence technologies in the food processing industry could significantly enhance the performance of corporations and gave the importance of intelligent transformation in improving the efficiency of the processes with concrete examples of its practical implementation in the process of digitalization in the enterprise (Wang & Liu, 2025). The main goal of this shift in the method of production is to make human resources more efficient, i.e. redeploying workers to positions of low-value-added activities in favor of research and development, design and customer services, and thereby increase the level of innovative power in society. Automation has become increasingly popular and most of the wasteful and inefficient manual operations of the traditional manufacturing have become obsolete to the workers who now concentrate on more creative endeavors. However, the food processing industry uses fresh, perishable raw materials and follows stringent safety instructions. Customized and flexible production line, with a special emphasis on manufacturing fresh or semi-finished foods, is a new trend in the technological innovation in the food processing industry.

Table 1. Summary of AI advantages, sector specific threats and direct governance actions in Agricultural and Food industry chain. Source: Author.

Industrial Chain Sub-Sectors	AI Core Enabling Advantage	Food Industry-Specific Risks	Governance Plan
Raw material cultivation	Smart water-fertilizer management; AI-driven pest, disease and pesticide-residue identification for crop growth	Uneven geographical distribution of training datasets; under-developed agricultural regions face insufficient risk early-warning capacity	Conventional algorithm fairness auditing; expanded standard sample database for specialized crops
food handling	Round-the-clock machine-vision sorting; flexible and adaptive AI-driven intelligent production lines	Automation of sorting-packaging processes creates re-employment pressure on middle-aged front-line workers, especially in county-level small workshops	Multi-phase internal job-transition training by enterprises; government-supported digital-skill subsidies and vocational-school cooperation for small processors
Food R&D	AI-assisted molecular modeling accelerates formulation screening and reduces R&D trial-and-error costs	R & D staff fail to apply mechanism knowledge; corporate core formulation leakage	Human-machine division of labor: AI selects recipes, humans complete verification.

https://doi.org/10.67728/sshi.2026.013

Warehousing and Distribution	Demand forecasting to reduce fresh-produce inventory waste; end-to-end food traceability and proprietary product coding	Consumer dietary-habit privacy leakage; supply-chain data tampering may compromise food safety	Implement three-tier food-industry data classification management; obtain users' written authorization before collecting personal data

2.2. Enhancement of the Management of Food Safety in the Whole Supply Chain to Improve Risk Prevention and Control Efforts

The accuracy of machine vision as a target recognition tool in determining food contamination and surface defects has been exceptionally high. Food safety is among the issues that should be guaranteed. Different from general industrial safety risks, food safety hazards directly threaten public physical health; therefore, AI early-warning systems for food chains bear higher public-safety obligations. Deep learning with convolutional neural networks and transfer learning techniques have gained extensive application in the food classification and defect detection task that are able to identify contaminants, fungal growth and other abnormalities and the recognition performance is significantly superior than manual inspection (Zhang et al., 2023).As it is stated in the literature by Ranganathan et al., the integration of expert systems, fuzzy logic, and neural networks with the sensors allows monitoring in real time depending on the level of food production, supply chain, and sensory analysis, providing new possibilities to fight food safety threats technically (Zatsu et al., 2024). Conversely, machine learning and deep learning techniques can analyze large volumes of non-linear data in the supply chain, and thus develop a holistic risk assessment framework that acts as an early warning system covering the whole industrial chain (Zhang et al., 2025). The extensive implementation of artificial intelligence in the agricultural and food industries is capable of solving many problems that arise during agricultural production, including the combined application of sensors in the cultivation process (to reduce the use of pesticides and chemicals), use of supply chain big data (a part of the distribution process) to provide monitoring services of the entire industry and detect the problem when it happens, not only enhance the management of food safety but also change the way it is managed i.e. transition of management model that emphasizes post-event accountability to proactive prevention (Aghababaei et al., 2025). As other researchers like Ikram Ali pointed out, AI could facilitate a very clean supply chain management system and it would improve the international food quality control and food safety initiatives; however, research on the perception of consumers based on big data shows that actions of regulators should consider the subjective emotional response of the populace to food safety threats (Jung et al., 2025; Ikram et al., 2024).With the assistance of artificial intelligence, it becomes simple and convenient to offer a wide variety of services to people such as intelligent food traceability systems and online information services about food safety regulations via a web portal, and therefore removes the inconvenience of queues and makes food safety regulation services more effective and easy to use. The underlying image recognition algorithms have the capability of cross-domain generalization, but because of the vast diversity of biological matrices used in the food sector (fruits, vegetables, meat, grains and fats and even frozen products) and the high number of interfering factors, the previously trained medical imaging models cannot be used in the field. It involves tailored iterative training to adjust these models to the particular interfering examples in the food sector.

2.3. Shorten the Food R&D Cycle to Drive Innovation in Functional Foods

Creation of traditional food products often demands that experts re-optimize the formulations, a procedure that consumes a great deal of time and is expensive. Nevertheless, it has been found out that with the help of AI-assisted molecular modeling and analysis of big data technologies, scientists can select the appropriate formulations, forecast the quality of goods and cut down expenses on the R&D costs (Zeng et al., 2025) (As show in Table 1). The recent literature has examined various different case studies of the application of AI technology in the food industry, including neural networks and predictive models, and can find connections between food ingredients and product quality, and develop a new paradigm of R&D that combines virtual pre-experiments and real experiments (Jayan et al., 2025). A considerable effort has been invested to demonstrate that AI is not restricted to the simple data processing alone but has the potential to change the research methodologies of conventional food science and speed up the rate of development of new products and reduce the costs of labor and time (Hoffman & Cozzolino, 2026). There are many large-scale and multifaceted computations that cannot be executed by human beings but can be outsourced to AI, allowing scholars to identify the new research opportunities and enhance their understanding of the respective fields. Yet, the food formulation should also consider other factors like taste, nutritional value and shelf life, which makes practical realization of the AI-optimized food formulations complicated.

2.4. The Optimization of Resource Allocation in the Industrial Chain as a Whole Will Help to Foster Green and Sustainable Development

The most acute problems in food manufacturing and storage processes include excessive raw material usage, energy and product wastage and through algorithmic scheduling such wasteful use of resources will be reduced, and more value will be added to the food supply chain. In their literature review, Reitano et al. have explored different applications of artificial intelligence within the

whole agriculture and food supply chains, noting that technological solutions like algorithmic scheduling and intelligent forecasting can be used to help optimize resources and reduce losses; they also suggest that the implementation of these technologies has been limited by such factors as the size of the production facility and the condition of the local infrastructure (Reitano et al.,2025). For instance, a confectionery company could discover the most effective methods to deploy warehouse robots by adjusting the scheduling processes, and the outcome of this would be lower energy consumption in transportation and waste reduction of the product (Božić et al., 2025). Literature supports the idea that the synergy of artificial intelligence and agriculture and food can be used as an agent of the sectoral development; smart water and fertilizer management systems can accurately provide water and nutrients on request, which saves water resources, reduces pollution in agriculture and ensures food security Harikrishnan et al., 2024), whereas greenhouses control systems could dynamically adjust the volume of irrigation, fertilization, and lighting depending on the growth stage of the plants (as show in Table 1), thus, eliminating water and electricity waste (Li et al., 2025). The current literature discusses the importance of artificial intelligence in resource optimization: in the course of manufacturing, this tool can be applied to regulate the energy consumption of the equipment in order to save electrical energy; in the process of storing, this tool helps to manage the inventory in a sensible manner through the prediction of demand, which results in reduced volume of waste and damaged food (Bidyalakshmi et al., 2025). Moreover, these algorithms can also suggest possible reuse opportunities of food waste and assist to develop economically feasible circular economic models, and hence contribute to the realization of green and low-carbon transformation of the industrial sector. However, the editorial by Belwal et al. also cautions the researchers that they ought not to concentrate on positive aspects of AI regarding minimization of losses and improvement on efficiency alone, but objectively evaluate the energy consumption and environmental effects of the large language and intelligent computing power and strike a balance between the benefits of the improved efficiency and environmental effects (Belwal et al., 2026). Ezzat et al. also point to the importance of considering the ecological footprint of the AI system when using AI to estimate the ecological footprint of the agricultural and food industries so as not to perceive the environmental benefit of the technology as unidirectional (Ezzat et al., 2026). However, the new agricultural produce, which can be disposed of naturally, and the application of artificial intelligence in demand forecasting to reduce inventory losses and allow the utilization of high-value processing waste as a low-carbon solution in the food industry is a novel approach.

3. Potential Risks and Drawbacks of Applying Artificial Intelligence in the Food Industry

3.1. Upsets the Conventional Patterns of Employment; Low-Skilled Employees Have Serious Difficulties in Changing Their Positions

The labor-intensive part of the food processing industry (sorting, inspection, and packaging) is especially well suited to automated activities by smart robots and this has been the area affected most by these paradigm shifts- a trend that is gaining momentum in the industry (Bidyalakshmi et al., 2025). With the high degree of popularity of the decision-making scheme of warehouse automation to manage fresh agricultural produce the manual manipulation of the goods in warehouses, particularly fresh fruits and vegetables, is decreasing and increased demands to hire novel versions of intelligent labor to perform both operations and maintenance are being made (Božić et al., 2025). Employment that is based on artificial intelligence, in the form of food data analysts and equipment maintenance technicians, requires extremely specialized professional qualifications of those who hold these positions; nonetheless, there are numerous individuals who do not get higher education or reach middle age or old age because of the shortcomings of their own abilities and are unable to develop the necessary digital competences within a short timeframe, and therefore, they cannot take part in retraining courses designed to provide them with these jobs. It is possible that this situation would lead to structural unemployment and inequality in the income of employees working in the industry. The automation of prepackaged foods manufacturing process will affect the front line workers in particular, and without support measures, it can lead to regional employment crisis (Huang et al., 2025). Moreover, despite the fact that the use of artificial intelligence has also produced some extra job opportunities, such as a data annotator or an AI trainer, employees experience a set of difficulties to get employed as they enter into a new, skill-based job. Unskilled workers in particular are very vulnerable to unemployment as they typically do not have the ability to acquire new skills at a fast rate or be trained into new roles rapidly and are highly prone to unemployment. The result will be an increase in the income differences between various workers and may result in a variety of social problems. Unlike standardized heavy-industry factories, food processing contains many small-and-county-level workshops; older front-line workers are long engaged in sorting fresh agricultural products (as show in Table 1). They lack digital-learning resources, and once displaced by automation, re-employment pressure is more prominent within the food sector.

3.2. The Centralization of Information at All Levels of the Industry Chain Amplifies the Risk of Data Security and Privacy

The amount of data that any AI system usually handles can be enormous, and this is the issue of personal data security. Moreover, improper use of the facial recognition technology may result in the development of the digital surveillance behaviors. Personal

data, including addresses, travel plans, health conditions, and even commercial secrets, can be stored in AI systems when customers use AI-based products. To ensure these AI systems do their job correctly, it is necessary to get large amounts of data across the whole manufacturing process; since these datasets contain a combination of corporate trade secrets and sensitive information about individual users, they must be highly confidential. It is necessary to have proprietary formulation information to produce functional foods, but the chances of such proprietary technologies being disclosed increase when companies integrate modeling and data sharing (Zeng et al., 2025) (As show in Table 1). Data privacy breaches and corporate trade secret leaks were determined as inevitable practical ethical issues that are associated with the application of food-related AI in their research on sustainable food design; the large supply chain data storage in one centralized location increases the likelihood of such leaks and abuses happening (Harikrishnan et al., 2025). The smart food revolution has also seen an increase in the need to gather data in the overall general and specific parts of the supply chain, including farm to supermarket (Song et al., 2025). Poor data security methods within an organization may cause the loss of trade secrets and at the same time, the infiltration of sensitive information by smart systems can be considered as infringement of individual privacy. If significant data are saved over a long period of time and then subjected to attack, this data may either end up to the wrong hands or be corrupted during its upstream or downstream processes, which will compromise the safety of foods (Aghababaei et al., 2025); if the data security protection systems of a company are not that strong or involved in the illicit business, it would violate the privacy of users. Different from ordinary industrial intellectual property, leaked functional-food formulas will directly bring food-safety imitation risks; consumer data include sensitive dietary and eating-habit information closely related to public health, so privacy leakage will produce special public-health-related hazards in food industry (as show in Table 1).

3.3. An Uneven Distribution of the Training Sample Creates Algorithmic Bias and an Industrial Injustice

The use of artificial intelligence is susceptible to reproducing and amplifying already existing unfair practices of specific industries when the training samples are not evenly distributed. Most of the food identification and grading models are based on the large datasets of agricultural products, which means that regional specialty foods and other special agricultural products are poorly represented in these models. These models fail to appreciate the quality of specialty products and this in turn adversely affects smallholder farmers or small and micro enterprises (Zhang et al., 2023). Moreover, there are serious differences in the volume of available information about the products of different geographical zones or kinds, which has been documented in end-to-end research carried out throughout the entire food system and agricultural value chain. Agricultural risk assessment models usually are intended to favor agriculture-oriented nations, whereas early warning systems are inadequate to agriculture-oriented underdeveloped countries, thus enhancing the gap in the degree of industrialization across different regions (as show in Table 1) (Harikrishnan et al., 2024). Smart technologies to operate greenhouses and machine learning algorithms to assess food safety risks are mainly trained on large scale standardized farms but because of the absence of data on smallholder farmers and specialized agricultural products, these smart management systems are often more useful to larger companies (Li et al., 2025; Zhang et al., 2025). These algorithms would grow the current inequities within the industrial sector by objective computational analysis and disrupt a fair competitive structure in the food industry; all intelligent adaptive systems that are applied to food processing industry are vulnerable to the action of unbalanced training datasets (Ayoub, 2026). The paper by Reddy et al. also identifies unbalanced training datasets and unbalanced market competition as one of the most severe ethical issues of food-related artificial intelligence, since it states that these models can reproduce natural inequalities of a real world, and put small-scale business owners at a disadvantageous position (Harikrishnan et al., 2025). In the food industry, algorithm bias caused by insufficient samples of regional special agricultural products will lead to underestimation of product grade, directly resulting in unsalable agricultural goods and income loss for smallholder producers—this consequence is unique to agri-food chains.

3.4. The Long-Term Use of Technology Has Caused a Decrease in the Level of Professional Competence of Practitioners

Too much focus on artificial intelligence can quickly result in diminishing humans' fundamental skills. Those who practice in the food industry and use AI to examine the products, create the formulas, and optimize the processes have had a slow reduction of their hands-on operation ability, analytical judgement, and creativity. Food visual inspection system example: the extensive use of machines by quality inspectors to detect defects can eventually result in their lack of ability to see small defects by hand, which has been observed by some studies (Zhang et al., 2023); the repeated application of automated material handling systems by warehouse managers to control the movement of goods may result in their inability to plan activities in the warehouse by hand and avoid the loss of stock; the great extent of dependence of greenhouse workers on the intelligent control system to do their job can leave them susceptible to forgetting their skill to conduct manual inspections of the environment where crops grow (Božić et al., 2025; Li et al., 2025); when R&D staff just applies the formulas given by AI without designing their own experimental or fundamental research, it

would merely speed up the process of new products creation, but not substitute the unique creative thinking of the scientists (Hoffman & Cozzolino, 2026) (as show in Table 1); in case when equipment or software does not work properly, then the operator might not know why the equipment or software stopped working, as it is very simple to endanger food safety. There is an ever-increasing tendency towards algorithm-based food processing, especially with the rise in intelligence of the industry, and such dependency could be harmful to innovation within the field of food science (Ayoub, 2026). When individuals get used to the standardized information and the automatic reactions offered by artificial intelligence, they start to slowly forget the ability to think critically or contemplate something; they may even lack the desire to explore some aspects or make independent choices. With time, this kills creativity in people, and creativity is exactly what pushes society forward. The main source of competitiveness in the food industry is the sensory assessment abilities and professional knowledge acquired through human experiences in traditional physical and chemical processing that cannot be replicated by programming. In food industry, manual sensory evaluation, defect discrimination and field growth judgment cannot be fully replaced by algorithms. Once practitioners over-rely on AI systems, manual defect-identification capability declines, which may trigger undetected food-safety hazards. This risk is more serious than many other manufacturing industries, because defective food products directly harm consumers' health.

4. The Best Strategy in Synergistic and Well-Balanced Development of Artificial Intelligence and the Food Industry

4.1. Create a Job Transition System in Order to Reduce the Effect of Automation on Jobs

Corresponding to the structural employment risks analyzed above, this section proposes job transition optimization strategies for the food industry. The government must reinforce its backing of vocational training, especially those jobs that are prone to being eliminated by artificial intelligence. The government has partnered with businesses to launch a Food AI Talent Training Camp, offering courses in intelligent operations and maintenance as well as food data processing for unemployed individuals. It may develop training programs that would solve the issues of Intelligent Warehouse Equipment Scheduling, Robotic Maintenance of Fresh Agricultural Products and Intelligent Greenhouse Control System Operation so as to meet the needs of transforming the human resources in the sphere of warehousing and materials handling, transportation of fruits and vegetables and operation of greenhouses (Božić et al., 2025; Li et al., 2025). In order to assist the large number of employees who have lost their jobs because of automated processing of prepackaged food, employers can provide specific reemployment training to the former employees who had performed sorting or cleaning tasks, enabling them to fill the new positions, such as overseeing the intelligent production line. Besides that, companies ought to be honest in carrying out their roles and develop multi-phase internal job transition training strategies to ease the process of moving employees who used to engage in sorting or inspection operations to new work, such as intelligent production line management or manual quality control (Huang et al., 2025). Faster adaptation of the higher education system to the Food Science and Engineering area is needed and the topic of food artificial intelligence and intelligent equipment should be added to the curriculum and curriculum offerings based on research findings across the entire supply chain to mitigate structural employment issues in the area of talent development (Bidyalakshmi et al., 2025). Unemployment insurance and reemployment assistance schemes must be enhanced; those who lose their jobs because of the impact of artificial intelligence must be offered temporary living allowances and job search assistance; as well, the promotion of flexible employment conditions and different kinds of employment must be made to expand the labor market and reduce the impact of artificial intelligence on the workforce. Considering that many small county-level food processors cannot afford high-end digital training, cooperation between local vocational schools and small food enterprises should focus on food-specific capacities: intelligent production-line food-hygiene supervision and manual sensory re-check of finished food products (as show in Table 1).

4.2. Improve the Overall Structure of the Data Governance Framework in the Whole Food Industry Chain in Order to Preserve the Basic Level of Data Security

In view of the industrial chain data security and privacy risks mentioned in the previous chapter, this study constructs a complete data governance framework. It is necessary to make sure that there are proper legal frameworks that are necessary to protect the security of data and provide sufficient legal restrictions throughout the process of both collecting and utilizing the information. The proposed food data classification system will include the control over the gathering, storage, and use of recipes data and consumer privacy data, along with the fact that personal data collection will be performed according to the rules. It is also worth noting that the data on recipes of the functional food companies is considered as highly valuable business secrets that need special attention during the collaborative AI modeling process with the involvement of a large number of stakeholders (Zeng et al., 2025). It is theoretically possible to satisfy the needs of data sharing between various stakeholders in the agricultural and food industries using security algorithm applications like federated learning and differential privacy, but there should be no data exchange on internal processes among the participants when several food companies train AI models together (Aghababaei et al., 2025). Also, a system

of regular food AI security audits needs to be put into place where periodic reviews of the food collection processes that are done in automated food production lines are undertaken, the close monitoring of the data transaction processes and the assurance that all the data security requirements of the enterprises should be satisfied by them entirely (Song et al., 2025). Moreover, it must be explained who are the owners of the data rights and what are the functions and responsibilities of each participant in the data flow process and all the responsibilities that are legal. Motivation of internet platforms and AI developers is required to increase their awareness of the importance of data security responsibility and some penalty conditions should be introduced to punish illegal processing of personal data to serve as an efficient deterrent measure. Food companies will have a tripartite system of data classification and management, namely: the first level will denote the general data (average customer data), the second level will mean confidential data (standardized and general processes of production) and the third level will be the highest level (corporate-developed functional foods formulations) (as show in Table 1). Each tier will have different conditions of storing and the requirement of external disclosure permission will vary.

4.3. Establish a Food AI Algorithm Review System and Enhance Industry-Wide Technical Ethics Guidelines

To solve the algorithm bias and industrial injustice caused by unbalanced training samples, this paper establishes a targeted algorithm review and ethical supervision system. The algorithm review shall prioritize food-industry-specific indicators: whether the grading algorithm can fairly evaluate special local agricultural products, whether the food-safety risk-assessment model adapts to small-farm production scenarios. The types of systems in greenhouse intelligent management and control systems, warehouse automated sorting systems, and machine learning-based food safety assessment systems can be divided into three categories, and it would require establishing expert fairness review criteria, and thus the same validation datasets could be generated to cover speciality agricultural products and small-scale processing plants and individual farmer-grown samples (as show in Table 1) (Božić et al., 2025; Li et al., 2025; Zhang et al., 2025). Additionally, the smart monitoring algorithms that are intentionally contaminating food should be reviewed ethically; here, the act of data collection should be reduced so that it cannot lead to excessive monitoring as excessive monitoring can undermine commercial interests (Puhač Bogadi et al., 2025). It is important that AI systems which have significant impacts on the common good must be open, as it means that all reasons underlying a decision must be available to the entire population. Food picture identification models and categorization models need to be evaluated often to check if they contain a bias in their datasets (Zhang et al., 2023). Intelligent processing technologies introduced to the industry should be assigned clear areas of implementation to make sure that algorithmic bias does not segregate small businesses and individual entrepreneurs and thus create fair competition among all food businesses (Ayoub, 2026). These ethical regulatory provisions also touch upon the issue highlighted by Reddy et al., which states that the introduction of AI in the food sector should not be based solely on performance indicators but it needs to help in the creation of ethical standards and the methods of evaluating them (Harikrishnan et al., 2025). Also, requirements regulating the distribution of responsibility of AI applications are necessary; in case the actions of an AI system violate the rights or interests of other people, then the responsibilities of the algorithm developers and its users should be clearly defined, and the necessary actions should be undertaken to provide the affected parties with the proper compensation. Moreover, in order to reduce the problem of unjust quality ratings of the agricultural product samples leading to oversupply, it is important to carry out third-party algorithm fairness audits based on large data sets with a greater diversity of local and regional conventional products.

4.4. Foster a Human–Machine Collaboration Mindset to Strengthen Humanity's Core Professional Advantages

Aiming at the degradation of practitioners' professional abilities caused by long-term technical dependence, this section advocates building a human-machine collaborative development model. Education should develop the critical thinking and innovative skills of the students, the two fundamental competencies that belong to humans alone and cannot be easily imitated by the AI. Food science relies heavily on human sensory evaluation, tasting and practical experimental judgment. AI is auxiliary tool for food formulation screening, but cannot replace human comprehensive judgment of taste, flavor and food safety. Training of intelligent algorithms can be combined with the development of personal practical skills through theoretical subjects like planning of warehouses and logistics, selecting fruits and vegetables manually, managing greenhouses and farmland, and manually testing human-caused food pollution (Božić et al., 2025; Li et al., 2025; Puhač Bogadi et al., 2025). It is encouraged that organizations take a human-machine division of labor approach: allowing machines to perform regular checks, data processing, and preliminary selection of recipes and enabling human workers to perform the work of process design, result analysis, independent creativity and risk management (as show in Table 1). More attention should also be paid to involving the population in the industrial sector and informing employees about the idea of artificial intelligence and not relying solely on it, but rather continuing manual labor, analyzing and making decisions themselves, and engaging in creative work, which would contribute to balancing intelligent effectiveness and enhancing the quality of work of employees (Bidyalakshmi et al., 2025). The organizational working environment should be designed so that there is a clear-cut separation of labour between humans and machines: the activities that are time-intensive and

repetitive and every other activity that can be regulated by stringent rules must be delegated to machines and the human workforce employed on the activities that require more communication, interaction, value orientation or creative exploration of the problems; this strategy will enable the organization to utilize its strengths and alleviate its weaknesses thus attaining effective cooperation. The Food Science and Engineering course curriculum framework should have enough laboratory time to conduct both practical experimental procedures including human sensory evaluation, physicochemical tests carried out in the field, AI-based simulation-based training could be considered as an extra type of training but should not be used instead of hands-on or experimental training with online virtual experimentation.

5. Conclusions

The current paper uses a novel two-dimensional analytical model, called Technological Empowerment of Risk Constraints, to identify four categories of typical real-world issues based on a body of empirical evidence about the application of artificial intelligence in the context of the food industry. Its purpose is to fill in one of the existing gaps in the previous AI-based studies; most of them were devoted to so-called general-purpose AI, whereas specific problems associated with specific fields of application were not addressed. The paper offers some recommendations to the stakeholders depending on four individual characteristics of the food industry that will help to eliminate the very generalized and impractical strategic directions that are usually taken in the current study. Among these double-edged swords is the idea of artificial intelligence: on the one hand, it can be used to increase the level of productivity and empower individuals, but on the other hand, it can change the nature of work and cause the fear of the insecurity of their own data. Technology is not inherently either good or bad, it all depends on the application of technology. Smart reaction of the food industry to the idea of artificial intelligence has turned into one of the crucial trends, thus, we cannot underestimate its significance because of some of its possible weaknesses and do not try to innovate without evaluating the risks involved. Through adherence to two fundamental principles of being people oriented and people oriented in terms of human-machine partnership, formulation of relevant institutional policies and development of governance structure according to the trends in the industry, we can utilize artificial intelligence most effectively to make the innovative advancement of the Chinese food science and engineering industry and satisfy the population needs on food nutrition and health. Being a student of Food Science and Engineering we can easily see that artificial intelligence makes a strong influence on this field. This research leads us to three major conclusions: First, artificial intelligence has moved into the food business, and can be applied to four of the traditional problems of the industry, which indicates the possibility of full scale applications of artificial intelligence; Second, the bulk implementation of AI has introduced four additional types of risks, which are harmful to the interests of most industries, and industries should pay more attention to the implementation of technologies, as well as the prevention and reduction of risks; Third, the food industry must follow the tenets of human-machine cooperation and balance, and the stake holders should take appropriate measures by engaging all the parties collectively to minimize the negative effect and maximize the positive effect. The application and subsequent development of AI in the food industry in the future needs to strike a balance between the technology innovation and human factors and use technology to smartly transform the food industry and create a futuristic ecosystem in the food industry.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data content is sourced from Web of Science, CNKI, and other similar databases.

Acknowledgments: The author would like to express gratitude for the support received during the completion of the Senior Research Project.

Conflicts of Interest: The author declare no conflict of interest.

References

Aghababaei, A., Aghababaei, F., Pignitter, M., & Hadidi, M. (2025). Artificial intelligence in agro-food systems: From farm to fork. *Foods, 14*(3), 411. https://doi.org/10.3390/foods14030411

Ayoub, A. (2026). Integration of artificial intelligence in food processing technologies. *Processes, 14*(3), 513. https://doi.org/10.3390/pr14030513

Belwal, T., Huang, R., & Zhao, H. (2025). Editorial: Defining the role of artificial intelligence (AI) in the food sector and its applications. *Frontiers in Nutrition, 12*, 1596699. https://doi.org/10.3389/fnut.2025.1596699

Bidyalakshmi, T., Jyoti, B., Mansuri, S. M., Srivastava, A., Mohapatra, D., Kalnar, Y. B., Narsaiah, K., & Indore, N. (2025). Application of artificial intelligence in food processing: Current status and future prospects. *Food Engineering Reviews, 17*, 27–54. https://doi.org/10.1007/s12393-024-09386-2

Božić, M., Dabić-Miletić, S., Andrejić, M., & Djurdjević, D. (2025). Ranking of autonomous technologies for sustainable logistics activities in the confectionery industry. *Mathematics, 13*(3), 498. https://doi.org/10.3390/math13030498

Ding, M., & Gao, Q. (2025). The impact of artificial intelligence technology application on total factor productivity in agricultural enterprises: Evidence from China. *Economic Analysis and Policy, 86*, 399–415. https://doi.org/10.1016/j.eap.2025.03.032

Ezzat, D., Soliman, M. M., Darwish, A., & Hassnien, A. E. (2026). An optimized and explainable artificial intelligence approach for environmental impact of the agri-food industry. *Environment, Development and Sustainability*. https://doi.org/10.1007/s10668-026-07507-x

Harikrishnan, S., Kaushik, D., Rasane, P., Kumar, A., Kaur, N., Reddy, C. K., Proestos, C., Oz, F., & Kumar, M. (2025). Artificial intelligence in sustainable food design: Technological, ethical consideration, and future. *Trends in Food Science & Technology, 163*, 105152. https://doi.org/10.1016/j.tifs.2025.105152

Hoffman, L. C., & Cozzolino, D. (2026). AI in food sciences and technology—Beyond the algorithms. *Critical Reviews in Food Science and Nutrition, 66*(1), 172–182. https://doi.org/10.1080/10408398.2025.2520397

Huang, J., Zhang, M., Mujumdar, A. S., & Li, C. (2025). AI-based processing of future prepared foods: Progress and prospects. *Food Research International, 201*, 115675. https://doi.org/10.1016/j.foodres.2025.115675

Ikram, A., Mehmood, H., Arshad, M. T., Rasheed, A., Noreen, S., & Gnedeka, K. T. (2024). Applications of artificial intelligence (AI) in managing food quality and ensuring global food security. *CyTA—Journal of Food, 22*(1). https://doi.org/10.1080/19476337.2024.2393287

Jayan, H., Min, W., & Guo, Z. (2025). Applications of artificial intelligence in food industry. *Foods, 14*(7), 1241. https://doi.org/10.3390/foods14071241

Jung, H., Yoon, H. H., & Cho, M. (2025). Exploring consumer perception of food insecurity using big data. *Foods, 14*(17), 2965. https://doi.org/10.3390/foods14172965

Li, K., Shi, J., Hu, C., & Xue, W. (2025). The intelligentization process of agricultural greenhouse: A review of control strategies and modeling techniques. *Agriculture, 15*(20), 2135. https://doi.org/10.3390/agriculture15202135

Nath, P. C., Mishra, A. K., Sharma, R., Bhunia, B., Mishra, B., Tiwari, A., Nayak, P. K., Sharma, M., Bhuyan, T., Kaushal, S., Mohanta, Y. K., & Sridhar, K. (2024). Recent advances in artificial intelligence towards the sustainable future of agri-food industry. *Food Chemistry, 447*, 138945. https://doi.org/10.1016/j.foodchem.2024.138945

Puhač Bogadi, N., Uršulin-Trstenjak, N., Šarkanj, B., & Dodlek Šarkanj, I. (2025). Food and agriculture defense in the supply chain: A critical review. *Applied Sciences, 15*(20), 11020. https://doi.org/10.3390/app152011020

Reitano, M., Segovia, M. S., & Nayga, R. M., Jr. (2025). A systematic review on the impact of artificial intelligence in the agri-food supply chain. *Food Policy, 137*, 102983. https://doi.org/10.1016/j.foodpol.2025.102983

Song, X., Zhang, X., Dong, G., Ding, H., Cui, X., Han, Y., Huang, H., & Wang, L. (2025). AI in food industry automation: Applications and challenges. *Frontiers in Sustainable Food Systems, 9*, 1575430. https://doi.org/10.3389/fsufs.2025.1575430

Wang, Y., & Liu, F. (2025). Impact of artificial intelligence innovation on food company performance. *International Review of Financial Analysis, 103*, 104219. https://doi.org/10.1016/j.irfa.2025.104219

Zatsu, V., Shine, A. E., Tharakan, J. M., Peter, D., Ranganathan, T. V., Alotaibi, S. S., Mugabi, R., Bin Muhsinah, A., Waseem, M., & Nayik, G. A. (2024). Revolutionizing the food industry: The transformative power of artificial intelligence—A review. *Food Chemistry: X, 24*, 101867. https://doi.org/10.1016/j.fochx.2024.101867

Zeng, F., Zhang, M., Law, C. L., & Lin, J. (2025). Harnessing artificial intelligence for advancements in rice/wheat functional food research and development. *Food Research International, 209*, 116306. https://doi.org/10.1016/j.foodres.2025.116306

Zhang, Q., Lu, Z., Liu, Z., Li, J., Chang, M., & Zuo, M. (2025). Application of machine learning in food safety risk assessment. *Foods, 14*(23), 4005. https://doi.org/10.3390/foods14234005

Zhang, Y., Deng, L., Zhu, H., Wang, W., Ren, Z., Zhou, Q., Lu, S., Sun, S., Zhu, Z., Gorriz, J. M., & Wang, S. (2023). Deep learning in food category recognition. *Information Fusion, 98*, 101859. https://doi.org/10.1016/j.inffus.2023.101859

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of Apollo and/or the editor(s). Apollo and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.