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Developments of Food Industry 4.0 in Europe

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Abstract

Food security risks are increasing due to the global population explosion and climate change. Therefore, it is necessary to develop plans to conserve resources and ensure their sustainability using modern technologies to achieve this purpose. This report aims to examine the advancements in the European Food Industry 4.0. The Fourth Industrial Revolution (Industry 4.0) is gaining traction as a critical driver of sustainable growth and a valuable catalyst for resolving global issues. Technology from the Fourth Industrial Revolution is now widely used in the food business, and its use has increased dramatically in recent years. These innovations will lower manufacturing costs, improve food safety and quality, use less energy and resources, and decrease food loss and waste. The use of technology 4.0 has accelerated over the past few years due to its high efficiency in the food industry. Therefore, this review aims to shed light on technology 4.0 in Europe and its development over the past. The food processing business is one of the numerous industrial sectors that industry 4.0 technologies have redefined and transformed in the last few years. Several Industry 4.0 technologies have become more well-known and thriving in the food, safety, and quality sectors.

Key Words: *Food Industry 4.0, Agriculture, Europe*

Introduction

In the last several years, our world has faced unheard-of difficulties, chief among them being climate change's severe and pervasive effects. In the meantime, as the world's population rises and is predicted to reach 9.7 billion by 2050, there will be a 56% increase in the need for food (van Dijk et al., 2021). Globally, the effects of climate change on government policies are complex and affect many facets of society, including the environment, politics, economy, and ecology. The consequences of different climates in different countries vary, as do the socioeconomics, infrastructure, institutional capacity, and resilience of health systems. Consequently, there are regional differences in the complexity and capability associated with the impacts of climate change on health (Abbass et al., 2022). The pace of population expansion and climate change will significantly disrupt the global food supply, leading to a host of nutritional issues shortly. As the world's population approaches 8 billion people, it will become more difficult for humanity to meet the expanding population's food demands. Climate change may impact food production, a severe worry (Bağdatlı et al., 2023). For instance, forests, crucial food sources in many places, may be destroyed by increasing sea levels brought on by climate change (Elsheikh et al., 2023). Climate change directly affects food security and the source of income for those working in the food industry, including value chains. Currently, the global population affected by famine reached its peak in 2014. Climate conditions hav an imbat on the Food Distributions rotu, makin it difficult for people to visit markets in a variety of ways physically. Heavy rain, snow, storms, bridges, road vandalism, and overflowing transit channels all imbat the infrastructure (Raj et al., 2022).

Food shortages are a growing concern, driven by rising temperatures. The likelihood of several 'breadbasket failures' leading to a shock in food prices is rising. For instance, the likelihood of maize production misplacement is more than 10% among the top four divisions that produce the most maize (87% of total output); this percentage increased from 7% each year under a two °C temperature rise to 86% under a four °C increase (Ogunkalu, 2024). However, there is hope in the potential of technological advancements. The food processing industry is expected to evolve to produce foods with higher nutritional value, less resource consumption, biodiversity preservation, and minimal environmental impact in resilient systems to meet this growing demand with complementary initiatives to end hunger and food insecurity (Sachs et al., 2019). Significant adjustments are required, particularly in the food processing business, even if this requirement is hoped to be satisfied. It is anticipated that the fundamental principles of our society will change and become more robust, adaptable, flexible, and sustainable. Technological advances are vital components that will enable progress in food processing toward solving current and future issues. Elevated connectivity and automation via computer power are critical elements that might revolutionize food production systems (Augusto, 2020). Over the last twenty years, advancements in artificial intelligence (AI), consumer technology, computer power, and connection have all contributed to increased accessibility and a surge in biotechnology, robotics, e-commerce, and nanotechnology research and development. Food production is

undergoing significant changes due to 'Big Data.' Beyond these developments, blending technologies not usually combined is starting to encroach on the digital, physical, and chemical-biological domains, encouraging the fusion of new scientific fields with the so-called conventional food sciences (Chapman et al., 2022).

The aforementioned alterations, in tandem with technology integration across the food production, storage, and packaging process and throughout the value chain, define the fourth industrial revolution. Among other things, his fourth revolution is determined by the absence of borders and rapid business changes (Lee et al., 2018). In essence, the goal of the Fourth Industrial Revolution, also known as Industry 4.0, is to establish intelligent processing systems by increasing high-level automation and connectivity (between sensors, devices, machines, and people, for example) (Morella et al., 2021). One of the fundamental elements of Industry 4.0 is its interdisciplinary character, which incorporates a wide variety of information from the digital, biological, and physical domains (Chapman et al., 2021). This combination of qualities is needed to improve food quality, decrease food loss, and encourage the development of more efficient production techniques. It is crucial to note that there is no global consensus on the elements of Industry 4.0 (Ghobakhloo, 2018). This study analyzes Europe's Food Industry 4.0 developments, highlighting the industry's prospects and challenges.

Developments of Food Industry 4.0 in Europe

The Industrial Revolutions were defined by the advent of revolutionary developments in industrial production, which were primarily connected to technological advancements. The first industrial revolution (18th–early 19th century) defined the initial shifts towards intensifying working activities by creating and upgrading steam engine-driven equipment. During this period, the textile, coal, iron, and chemical industries flourished, and the production of certain food items shifted from home to factory settings (Koetsier, 2019).

The first industrial revolution's increasing mechanization and the extension and intensity of working activities led to the second industrial revolution in the 19th–early 20th century.

In addition, electricity became more common and replaced steam-powered equipment in industrial settings, which made large-scale production possible (Zhang & Yang, 2020). In the second decade of the 20th and early 21st centuries, the transition from analog to digital electronic systems signaled the start of the third industrial revolution, often known as the digital revolution. Significant technology developments like computers and the Internet have made it possible to communicate more quickly and interact with people worldwide. Electronic systems were also used for automation in manufacturing. To fulfill the growing demand from industrial, public, and domestic users throughout this time, nuclear energy research and application became more crucial (Xu et al., 2018).

Industry 4.0, or the contemporary 4IR (early 21st century), is defined by fully automated processes, integration with digital technology, and an emphasis on the Internet above all other factors. This ongoing change, which combines digital, biological, and physical components, enables real-time networking and communication among all industry stakeholders (Maynard, 2015). Mass production automation incorporates customization and personalized products. The growth of Industry 4.0 is linked to several essential variables, including digital twins, CPS, big data, blockchain, artificial intelligence (AI), intelligent sensors, cybersecurity, the Internet of Things (IoT), robotics, and cybersecurity. The food industry's production and operational efficiency have increased thanks to these cutting-edge digital and other emerging technologies. However, they have also negatively affected environmental sustainability and particular disturbances to the food supply chain (Olah et al., 2020). Robots are predominantly used in the food processing sector for pick-and-place operations such as packaging, sorting, and packing (Wang et al., 2022).

Robotic automation functions optimally when it addresses or improves specific manufacturing and processing scenarios (Dzedzickis et al., 2022). Robotics allows for rapid and straightforward reconfiguration into new work environments and procedures. Repetitive motion also reduces worker injuries, improving the working environment. Reduced production times and costs, as well as reduced waste material, were guaranteed by increased productivity. These benefits ensure that the company will always have an advantage over competitors. Robotics and Sector 4.0 technologies have long been used in food processing applications. However, their adoption rates are still low because of specific issues that need to be resolved before they can be widely used in the food sector.

For example, the food industry's stringent hygienic standards to guarantee food safety are among these problems, as are financial obstacles resulting from the exorbitant prices of buying and operating robotics at the moment (Wang et al., 2022). Artificial biomimetic technologies (E-noses, E-tongue, and computer vision) are clever techniques used in food processing based on appearance, taste, and smell variations. Chemical sensors, equipped with an AI system with access to a database of potentially harmful odors, can accurately discern between different food odors.

E-noses might be helpful in a food processing setting to help detect pollutants. For example, an E-nose with chemo-metric methods might be a trustworthy tool for tracking food drying procedures (Sun et al., 2019). Additionally, computer vision can disclose food's nutritional content (Kakani et al., 2020). Imaging and sensing sensors can also detect food residue on equipment. AI can also grade food cleanliness, monitor temperatures, and ensure employees wear the appropriate PPE. Monitoring tools can identify and follow individuals, their movements, and their clothes.

Face and object recognition may detect Masks or hair coverings (Kumar et al., 2021). Food safety is a critical concern in the food industry. Better monitoring using networked sensors makes it easier to identify food processing safety concerns and take action before the contamination spreads. As a result, IoT can identify safety concerns earlier than conventional techniques and instantly communicate the relevant data to take immediate action. It guarantees little production disruption and minimizes safety hazards while avoiding the need to spend resources for a batch that would otherwise have to be thrown out and squandered (Hassoun et al., 2023). IoT and biosensors can detect food contamination and send notifications that immediately cut off supply lines (Zhang et al., 2022). Food quality evaluations, food safety, and food production use IoT technologies in various ways.

The technologies that constitute Industry 4.0 as a whole and food processing technologies grew simultaneously as advancements in food science. Combining these two improves food safety and quality while catering to customer tastes and developments in the food processing sector (Hassoun et al., 2023). By leveraging our technical expertise on the global food system, we can develop standards, guidelines, and testing protocols that will enable the food business to adopt sustainable and, most importantly, safer practices. Furthermore, one area where technology may profit from a deeper comprehension of the content of food is native production (Serazetdinova et al., 2019). Therefore, technology 4.0 has accelerated over the past few years due to the food industry's high efficiency.

Conclusion

The Fourth Industrial Revolution is becoming increasingly popular as a catalyst for sustainable growth and a way to address previously recognized global problems. The food industry has recently significantly increased its use of Fourth Industrial Revolution-era technologies. These developments will lower production costs, improve food quality and safety, conserve energy and resources, and reduce food loss and waste. One of the numerous industrial areas in which business 4.0 technologies are redefining and transforming is the food processing industry, which has recently attracted much attention.

Advances in food science have led to a corresponding rise in food processing technology and the technologies that make up Industry 4.0 as a whole. Several Industry 4.0 technologies have been more widely accepted and thriving in the food, safety, and quality sectors in recent years. We can develop standards, guidelines, and testing procedures that will enable the food sector to adopt sustainable and, most crucially, safer practices by pooling our technical knowledge of the global food system.

References

Abbass K, Qasim M Z, Song H, Murshed M, Mahmood H, Younis I. 2022. A review of the global climate change impacts, adaptation, and sustainable mitigation measures. Environmental Science and Pollution Research, 29(28), 42539-42559.

Augusto P E. 2020. Challenges, trends, and opportunities in food processing. Current Opinion in Food Science, 35, 72-78.

Bağdatlı M C, Uçak I, Elsheikh W. 2023. Impact of Global Warming on Aquaculture in Norway. International Journal of Engineering Technologies and Management Research. 10(3), 13–25.

Chapman J, Power A, Netzel M E, Sultanbawa Y, Smyth H E, Truong V K, Cozzolino D. 2022. Challenges and opportunities of the fourth revolution: a brief insight into the future of food. Critical Reviews in Food Science and Nutrition, 62(10), 2845-2853.

Elsheikh W, Uçak İ, Bağdatlı M C. 2023. Food Crisis and Global Warming in Africa. International Congresses of Turkish Science and Technology Publishing, 495-500.

Ghobakhloo M. 2018. The future of manufacturing industry: a strategic roadmap toward Industry 4.0. Journal of Manufacturing Technology Management, 29(6), 910-936.

Hassoun A, Jagtap S, Trollman H, Garcia-Garcia G, Abdullah N A, Goksen G, ... Lorenzo J. M. 2023. Food processing 4.0: Current and future developments spurred by the fourth industrial revolution. Food Control, 145, 109507.

Kakani V, Nguyen V H, Kumar B P, Kim H, Pasupuleti V. R. 2020. A critical review on computer vision and artificial intelligence in food industry. Journal of Agriculture and Food Research, 2, 100033.

Koetsier T, Koetsier T. 2019. The first wave of industrial revolution: Cotton textiles and pig iron. The Ascent of GIM, the Global Intelligent Machine: A History of Production and Information Machines, 177-207.

Kumar I, Rawat J, Mohd N, Husain S. 2021. Opportunities of artificial intelligence and machine learning in the food industry. Journal of Food Quality, 2021(1), 4535567.

Lee M, Yun J J, Pyka A, Won D, Kodama F, Schiuma G, ... Zhao X. 2018. How to respond to the fourth industrial revolution, or the second information technology revolution? Dynamic new combinations between technology, market, and society through open innovation. Journal of Open Innovation: Technology, Market, and Complexity, 4(3), 21.

Morella P, Lambán M P, Royo J, Sánchez J. C. 2021. Study and analysis of the implementation of 4.0 technologies in the agri-food supply chain: A state of the art. Agronomy, 11(12), 2526.

Ogunkalu O. 2024. The Impact of Climate Change on Countries in the World. Eurasian Journal of Agricultural Research, 8(1), 77-84.

Olah J, Aburumman N, Popp J, Khan M A, Haddad H, Kitukutha N. 2020. Impact of Industry 4.0 on environmental sustainability. Sustainability, 12(11), 4674

Raj S, Roodbar S, Brinkley C, Wolfe D. W. 2022. Food security and climate change: differences in impacts and adaptation strategies for rural communities in the global south and north. Frontiers in Sustainable Food Systems, 5, 691191.

Sachs J D, Schmidt-Traub G, Mazzucato M, Messner D, Nakicenovic N, Rockström J. 2019. Six transformations to achieve the sustainable development goals. Nature sustainability, 2(9), 805-814.

Serazetdinova L, Garratt J, Baylis A, Stergiadis S, Collison M, Davis S. 2019. How should we turn data into decisions in AgriFood?. Journal of the Science of Food and Agriculture, 99(7), 3213-3219.

Sun Q, Zhang M, Mujumdar A. S. 2019. Recent developments of artificial intelligence in drying of fresh food: A review. Critical reviews in food science and nutrition, 59(14), 2258-2275.

Van Dijk M, Morley T, Rau M L, Saghai Y. 2021. A meta-analysis of projected global food demand and population at risk of hunger for the period 2010–2050. Nature Food, 2(7), 494-501.

Xu M, David J M, Kim S. H. 2018. The fourth industrial revolution: Opportunities and challenges. International journal of financial research, 9(2), 90-95.

Zhang C, Yang J. 2020. Second industrial revolution. A history of mechanical engineering, 137-195.