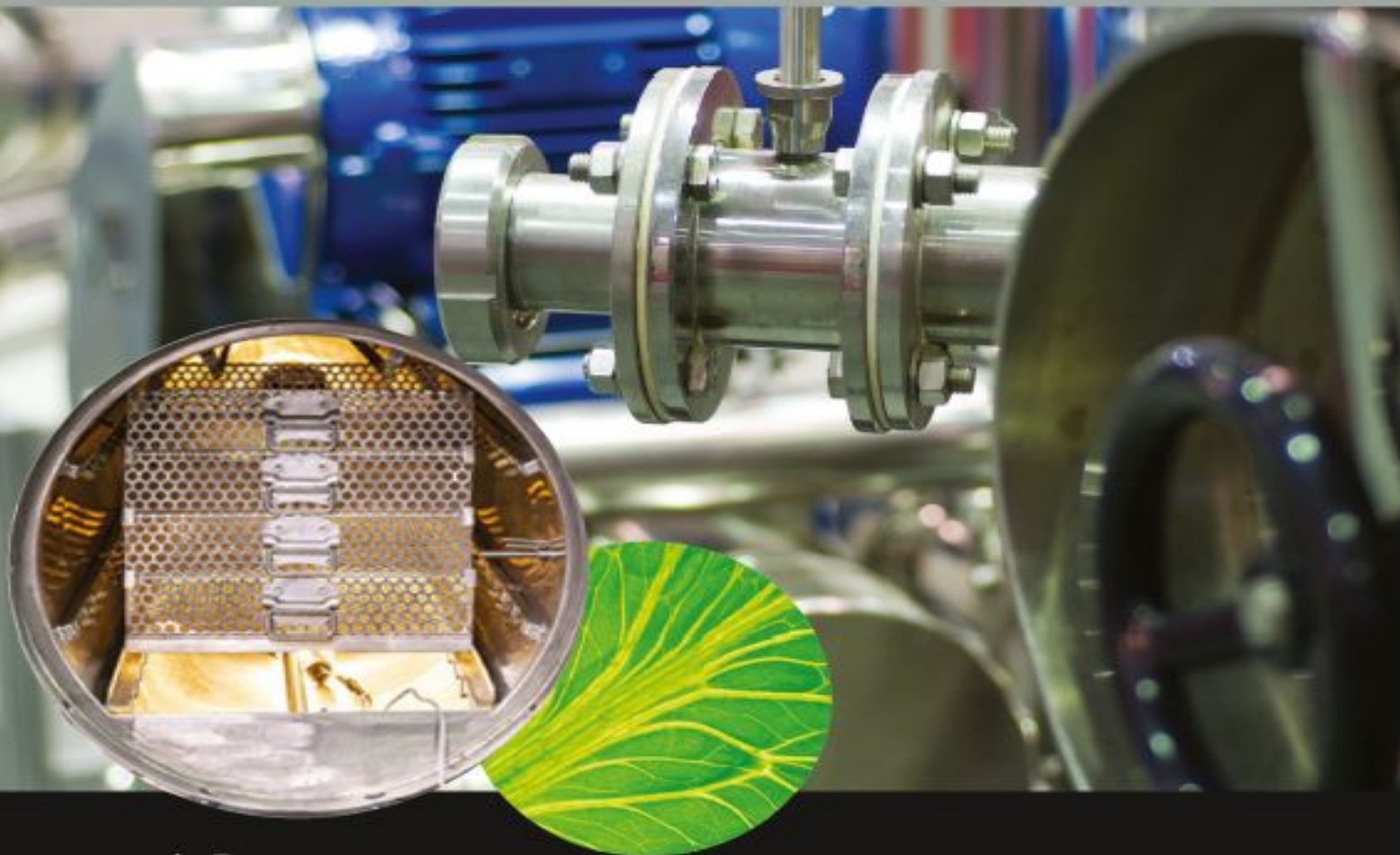


BIOPROCESSING IN FOOD SCIENCE

# NONTHERMAL FOOD ENGINEERING OPERATIONS

Editors

Nitin Kumar, Anil Panghal *and* M.K. Garg



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**Bioprocessing in Food Science**

**Series Editor: Anil Panghal, PhD**

**Scope: Bioprocessing in Food Science** a series of volumes covering the entirety of food science, unit operations in food processing, nutrition, food chemistry, microbiology, biotechnology, physics and engineering during harvesting, processing, packaging, food safety, and storage and supply chain of food. The main objectives of this series are to disseminate knowledge pertaining to recent technologies developed in the field of food science and food process engineering to students, researchers and industry people. This will enable them to make crucial decisions regarding adoption, implementation, economics and constraints of the different technologies. Bioprocessing has revolutionised the food industry by allowing for more efficient and sustainable production methods. This comprehensive series focused on microbial fermentation, enzyme technology, genetic engineering, microbial transformations, and bioreactor design. As we continue to face challenges such as population growth and climate change, bioprocessing will play an increasingly important role in ensuring a sustainable food supply for future generations.

Manufacturers are looking for new opportunities to take a significant position in a food market that is continually changing as demand for healthy food rises in the current global environment. In the current scenario, academia, researchers and food industries are working in a scattered manner and different technologies developed at each level are not implemented for the benefits of different stake

holders. Compiled reports and knowledge on bioprocessing and food products is a must for industry people. However, the advancements in bioprocesses are required at all levels for betterment of food industries and consumers.

The volumes in this series are comprehensive compilations of all the research that has been carried out so far, their practical applications and the future scope of research and development in the food bioprocessing industry. The novel technologies employed for processing different types of foods, encompassing the background, principles, classification, applications, equipment, effect on foods, legislative issue, technology implementation, constraints, and food and human safety concerns are covered in this series in an orderly fashion. These volumes are comprehensively meeting the knowledge requirements for the curriculum of undergraduate, postgraduate and research students for learning the concepts of bioprocessing in food engineering. Undergraduate, post graduate students and academicians, researchers in academics and in the industry, large- and small-scale manufacturers, national research laboratories, all working in the field of food science, agri-processing and food biotechnology will be benefitted.

*Publishers at Scrivener*

Martin Scrivener ([martin@scrivenerpublishing.com](mailto:martin@scrivenerpublishing.com))  
Phillip Carmical ([pcarmical@scrivenerpublishing.com](mailto:pcarmical@scrivenerpublishing.com))

# **Nonthermal Food Engineering Operations**

Edited by

**Nitin Kumar**

**Anil Panghal**

and

**M. K. Garg**



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## Preface

The book, *Nonthermal Food Engineering Operations*, in the “Bioprocessing in Food Science” series is an up-to-date and comprehensive overview of this area. Written and edited by a team of experts in the field, this book covers topics such as artificial intelligence usage in food industry, ultrasound, biosensors, cold plasma, extrusion process, image processing, active packaging, membrane processing, nanotechnology, supercritical and subcritical fluid extraction, utilization of ultraviolet rays in technological processes, and food safety concerns. The engineering and science aspects of these technologies are significant component of the undergraduate and postgraduate degree programs in Biological and Agricultural Engineering, Food Engineering, Food Science & Technology, and Nutrition & Health Science throughout the world. These novel technology operations in food processing are considered as one of the core competencies for these programs and in industries as well. Researchers around the globe will be able to use the information as a guide in establishing the direction of future research on nutritional properties during food processing. The main reason for writing this book now is to disseminate the wealth of knowledge on novel processing and its effects on food products. It is envisioned for scientists; technologists/engineers working in the area of food processing, process equipment design, and product development; and students of food science, technology, nutrition, health science, and engineering. It will enable them to make informed decisions regarding adopting appropriate processing technology, implementation, economics, and constraints of different technologies. As the demand for healthy, nutritious, and safe food increases, manufacturers are looking for new

possibilities to occupy a growing share of the rapidly changing food market. The book covers a range of emerging topics, from concepts to applications of different nonthermal processes in food engineering operations and their implications in nutritional sciences, nanotechnology in food systems, applications of nano-materials in the food system, emerging techniques in food preservation, and food safety and quality assurance in the food chain. The book also provides insights on advances in nonthermal technology for healthy and safe nutrition with illustrations of how to ensure public health safety. The authors and editors discussed the need for innovative food products, contamination in the food chain, risk assessment, regulatory frameworks, and their challenges within the context of the food engineering in the global food market.

Thanks are due to all authors for contributing their knowledgeable chapters in this volume and helping us to complete the book. We also thank the authorities of Chaudhary Charan Singh Haryana Agricultural University, Hisar (India) for their help and support. Finally, we also express indebtedness and thankfulness to Scrivener Publishing and Wiley team for their unfailing guidance and helpful assistance.

*Editors*

**Nitin Kumar**

**Anil Panghal**

**M. K. Garg**

# 1

## Artificial Intelligence (AI) in Food Processing

**S. Abinaya<sup>1</sup>, Anil Panghal<sup>2</sup>, Sunil Kumar<sup>2</sup>, Anju Kumari<sup>1</sup>, Nitin Kumar<sup>2</sup> and Navnidhi Chhikara<sup>3\*</sup>**

*<sup>1</sup>Centre of Food Science and Technology, Chaudhary Charan Singh Haryana Agricultural University, Hisar, India*

*<sup>2</sup>Department of Processing and Food Engineering, AICRP-PHET, Chaudhary Charan Singh Haryana Agricultural University, Hisar, India*

*<sup>3</sup>Department of Food Technology, Guru Jambheshwar University of Science and Technology, Hisar, India*

### **Abstract**

The food processing sector holds a significant place among other business sectors globally that support high employability. The efficient production and packing of food products depend greatly on the human workforce. Owing to the involvement of the human workforce, the food industries are not only unable to maintain food safety but also the demand-supply chain. Food is a basic human need. Reducing food waste, streamlining the supply chain, and improving food delivery, logistics, and safety are imperative. The most efficient approach to address these problems in the food industry is through industrial automation. Artificial Intelligence (AI) plays a significant role in achieving these goals. AI is defined as a branch of study that mimics human thought processes, learning abilities, and knowledge storage systems. AI has become an integral part of technological advancements in the food

industry in recent years as a result of growing food demands spurred on by a growing world population. The food industry is becoming more and more in need of these intelligent systems due to their versatility for performing tasks like food quality assessment, quality control, classification of foods, food processing, and forecasting. The numerous applications of artificial intelligence in the food sector will grow as a result of ongoing technological advancements and a wider range of application scenarios. This chapter helps to shed light on cutting-edge AI and its technologies in the food processing sector. The first part of this chapter explains what is AI, its components, techniques, and the ways forward its popularity in various sectors. The second part of this chapter provides insight into the various food processing applications of different AI technologies including Machine learning, Expert systems, Fuzzy logic systems, and machine vision, etc., It also discusses their benefits, drawbacks, and approaches to provide guidance for choosing the best approaches to advance future developments related to AI and the food industry. Furthermore, it also explains the efficiency of the use of combinations of two or more AI techniques to make tedious process and applications simple. In day-to-day life, the application of AI continues to grow because of its ability to improve waste management and maintain food quality, hygiene, and safety. In the future, AI significantly changes the food processing sector by producing more reasonable and healthier productivity for the growing population.

**Keywords:** AI, emerging technologies, expert system, neural networks, fuzzy logic, food industry, quality assessment, food safety

## **1.1 Introduction**

With the advancement of mechanization, the processing sector and current industry have reached productivity peaks in a matter of decades. The processing sector was the first to be transformed by technology developments and many other industries followed (Volter, 2013). In the early 1900s, the thought of automation performing jobs with more precision and eliminating human labor in all disciplines was a vision of hope for a better future. Artificial Intelligence, popularly known as AI, has risen to prominence in recent times, surpassing humans in activities such as object identification and data analysis (Cohen & Feigenbaum, 2014). While learning systems and processing capacity improve, this scenario appears to make a significant step forward. The origins of automation may be traced back to the early 1800s when it enabled the manufacturing sector, which eventually led to current technical advancements (MacLeod, 2002). Automation has now infiltrated nearly all fields and is outperforming market trades by a wide margin (Frohm *et al.*, 2008). The majority of equipment in the 18th century was designed to do simple operations like welding, spinning, and repetitive activities, allowing human workers to focus on more sophisticated activities (Mantoux, 2013). From the early 1900s until the present, various forms of automation have appeared in a few instances, ultimately turning their attention to a wide range of sectors. Nevertheless, recent advances in AI have caused humanity to reconsider the potential of learning and ask, "What might be the depths of AI when machines can learn?". AI is a collection of various approaches and phenomena, amid which two fundamental principles, Neural Networks (NN) and Deep Learning (DL), are credited for AI's remarkable progress (Norvig, 2002). AI is a term used to describe computer-generated intelligence that can develop to analyze, plan, comprehend, and interpret human language (Wang, 2008). It is the study and creation of digital systems capable of doing activities

that would ordinarily need human intellect, such as vision, speech identification, strategic planning, and language processing (Kumar, 2018). The pioneer of AI, John McCarthy, described it as the science and engineering of creating intelligent devices, particularly intelligent computer programs. Artificial intelligence can be divided into two categories: strong AI and weak AI. The weak AI principle states that the computer should be built to serve as an intelligent element that mimics human decisions, but the strong AI concept states that the machine should be able to reflect the human brain (Borana & Jodhpur, 2016). AI has a range of algorithms to pick from including reinforcement learning, Expert Systems (ES), Fuzzy Logic (FL), Swarm Intelligence, Turing Test, Cognitive Science, Artificial Neural Networks (ANN), and logic programming (Borana & Jodhpur, 2016). AI's seductive potential has earned it the most popular tool to use in fields such as decision-making and process optimization, intending to lower total costs, improve quality, and increase profitability (Ge *et al.*, 2017; Mahadevappa *et al.*, 2017). Food demand is expected to increase from 59 to 98% by 2050, as the world's population grows (Elferink *et al.*, 2016). Consequently, AI was used to meet this food demand in areas such as supply chain management, food sorting, production development, food quality enhancement, and adequate food hygiene (Funes *et al.*, 2015). ANN was used to assist complicated problem-solving in the food industry (Funes *et al.*, 2015), and the classification and prediction of variables are simple and easier when using ANN (Correa *et al.*, 2018), which has resulted in a growing demand for ANN over the past year. In addition, FL and ANN were performed as controllers in the areas of food safety, quality management, yield increase, and reducing costs (Kondakci & Zhou, 2017; Wang *et al.*, 2017).

## 1.2 Evolution of Artificial Intelligence

For scientists, Artificial Intelligence is not a new term or technique. This technique is much older. In Ancient Greek and Egyptian mythologies, there are even tales of mechanical men. The achievements in the history of AI that outline the route from AI formation to current development are listed below (McCorduck & Cfe, 2004):

- Warren McCulloch and Walter Pitts published the first study on artificial intelligence in 1943, which is today known as AI. They presented an artificial neuron approach.
- In the year 1949, Donald Hebb developed an updated rule for altering the intensity of neuron connections. He named the rule Hebbian Learning.
- In the year 1950, Alan Turing, an English mathematician, invented the machine learning system. In his paper "Computing Machinery and Intelligence," Alan Turing proposes a test. A Turing test can be used to determine whether or not a machine can demonstrate intelligent behavior comparable to human intelligence.
- In the year 1955, Allen Newell and Herbert A. Simon built "Logic Theorist," the "first artificial intelligence program." This program verified 38 of 52 mathematical theorems, as well as discovered new and more concise solutions for several of them.
- At the Dartmouth Conference in 1956, John McCarthy, an American computer scientist, coined the term "Artificial Intelligence." AI became a recognized academic discipline for the first time. High-level computer languages such as FORTRAN, LISP, and

COBOL were created during the period. There was a lot of interest in AI during this period.

- In the year 1966, the focus of researchers was on inventing algorithms that could solve mathematic problems.
- In the year 1972, Japan produced WABOT-1, the world's first intelligent humanoid robot.
- The first AI winter took place between 1974 and 1980. The AI winter represents a duration when computer scientists faced a severe lack of government support (funds) for AI research. Throughout AI winters, there was a drop in public interest in AI.
- After a brief hiatus, AI returned with Expert System. Expert systems have been built to mimic the abilities of a human expert to make decisions.
- Between 1987 to 1993, the AI Winter lasted for the second time. Investors and the government have once again halted funding for AI research, citing excessive costs and ineffective results. XCON, for example, was a very cost-effective expert model.
- In the year 1997, IBM Deep Blue defeats Gary Kasparov, the global chess champion, and becomes the first computer to defeat a world chess champion.
- In the year 2002, AI made its first appearance in the house in the Roomba vacuum cleaner.
- In the year 2006, artificial intelligence (AI) was introduced into the business world.
- In the year 2011, IBM's Watson won Jeopardy, a game show in which it had to tackle difficult questions and puzzles. Watson demonstrated that it could comprehend plain language and solve complex problems fast.

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