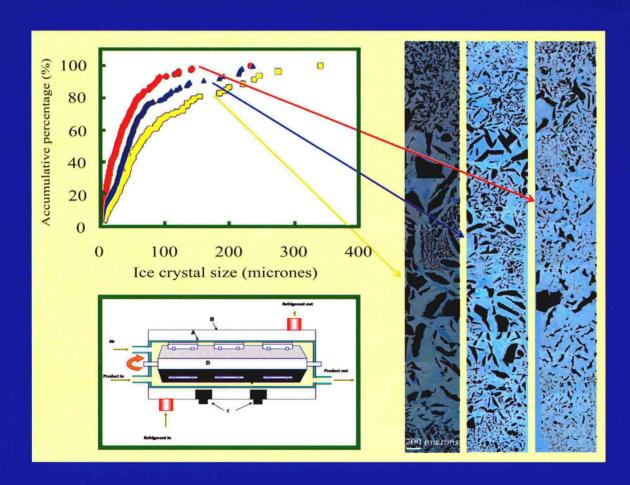
# EMERGING TECHNOLOGIES FOR FOOD PROCESSING

#### **SECOND EDITION**



EDITED BY

DA-WEN SUN



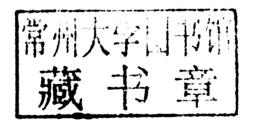
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DA-WEN SUN

University College Dublin, National University of Ireland, Dublin, Ireland







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### EMERGING TECHNOLOGIES FOR FOOD PROCESSING

SECOND EDITION

# Preface to the 2nd Edition

Driven by new knowledge and new techniques developed through research findings and by market demand, the food industry is very active in technological innovation with a good track record in searching for new ways of processing foods. However, with the increasing demand from consumers for enhanced food safety and quality, challenges for developing and adopting novel and advanced processing techniques are still facing the food industry.

The 1st edition of *Emerging Technologies for Food Processing* was published in 2005, with the main aims of presenting a comprehensive review of innovations in food processing, stressing topics vital to the food industry, and pinpointing the trends in future research and development, to provide food engineers and technologists with valuable sources of information for further research and developments for the food processing industry, and to serve as an essential and comprehensive reference source for undergraduate and postgraduate students and researchers in universities and research institutions. This will continue to be the purpose of this 2nd edition.

In the 2nd edition, as well as updating or rewriting individual chapters to include the latest developments

in each topic area, five new chapters have been added. In the past several years, the use of high-pressure processing has become widespread in the food industry with a diverse range of food products being treated, therefore two new chapters are added in Part I to reflect this trend. Recently, cold plasma and ozone have emerged as effective technologies for food decontamination, and two new chapters are thus included to cover these two topics in Part III. In addition, in Part IV, the content on nuclear magnetic resonance technology was not in harmony with the rest of this part, so this has been is replaced with a chapter on infrared heating. Finally, in Part V, a new chapter on improving freezing technology by electrical and magnetic fields is included, since this is an emerging technology in the refrigeration area.

#### Professor Da-Wen Sun, Director

Food Refrigeration and Computerised Food Technology; National University of Ireland, Dublin (University College Dublin), Agriculture & Food Science Centre, Belfield, Dublin 4, Ireland

# Editor Biography



Born in Southern China, Professor Da-Wen Sun is a world authority in food engineering research and education; he is a member of Royal Irish Academy, which is the highest academic honor in Ireland, and also a member of Academia Europaea (The Academy of Europe), and a Fellow of International Academy of Food Science and Technology. His main research activities include cooling, drying, and refrigeration processes and systems, quality and safety of food products, bioprocess simulation and optimization, and computer vision technology. His many scholarly works have become standard reference materials for researchers in the areas of computer vision, computational fluid dynamics modeling, vacuum cooling, etc. Results of his work have been published in over 700 papers including about 350 peer-reviewed journal papers (Web of Science h-index = 50; Google Scholar h-index = 63). He has also edited 13 authoritative books. According to Thomson Reuters's Essential Science Indicators<sup>SM</sup> updated as of July 1, 2010, based on data derived over a period of 10 years and four months (January 1, 2000-April 30, 2010) from ISI Web of Science, a total of 2554 scientists are among the top 1% of the most cited scientists in the category of Agricultural Sciences, and Professor Sun tops the list with his ranking of 31.

He received a first class BSc Honors and an MSc in mechanical engineering, and a PhD in chemical engineering in China before working in various universities in Europe. He became the first Chinese national to be permanently employed in an Irish University when he was appointed as a college lecturer at the National University of Ireland, Dublin (University College Dublin) in 1995, and was then continuously promoted in the shortest possible time to senior lecturer, associate professor, and full professor. Dr Sun is now Professor of Food and Biosystems Engineering and Director of the Food Refrigeration and Computerized Food Technology Research Group at University College Dublin (UCD).

As a leading educator in food engineering, Professor Sun has contributed significantly to the field of food engineering. He has trained many PhD students, who have made their own contributions to the industry and academia. He has also given lectures on advances in food engineering on a regular basis in academic institutions internationally, and delivered keynote speeches at international conferences. As a recognized authority in food engineering, he has been conferred adjunct/ visiting/consulting professorships from 10 top universities in China including Zhejiang University, Shanghai Jiaotong University, Harbin Institute of Technology, China Agricultural University, South China University of Technology, Jiangnan University, and so on. In recognition of his significant contribution to food engineering worldwide and for his outstanding leadership in the field, the International Commission of Agricultural and Biosystems Engineering (CIGR) awarded him the "CIGR Merit Award" in 2000 and again in 2006, the Institution of Mechanical Engineers (IMechE) based in the UK named him "Food Engineer of the Year 2004", in 2008 he was awarded the "CIGR Recognition Award" in honor of his distinguished achievement of being in the top 1% of agricultural engineering scientists in the world. In 2007 he was presented with the only "AFST(I) Fellow Award" in that year by the Association of Food Scientists and Technologists (India). In 2010 he received the "CIGR Fellow Award": the title of Fellow is the highest honor in CIGR, and is conferred to individuals who have made sustained, outstanding contributions worldwide. In March 2013, he was presented with the "You Bring Charm to the World Award" by Hong Kong based Phoenix Satellite Television, with other recipients including Mr Mo Yan-the 2012 Nobel Laureate in Literature and the Chinese Astronaut Team for Shenzhou IX Spaceship, and in July 2013 he received "The Frozen Food Foundation Freezing Research Award" from International Association for Food Protection (IAFP) for his significant contributions to enhancing the field of food freezing technologies. This is the first time that this prestigious award has been presented to a scientist outside the USA.

He is a Fellow of the Institution of Agricultural Engineers and a Fellow of Engineers Ireland (the Institution of Engineers of Ireland). He has also received numerous awards for teaching and research excellence, including the President's Research Fellowship, and has twice received the President's Research Award of University College Dublin. He is Editor-in-Chief of

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Food and Bioprocess Technology—an International Journal (Springer) (2012 Impact Factor = 4.115), Series Editor of "Contemporary Food Engineering" book series (CRC Press/Taylor & Francis), former Editor of Journal of Food Engineering (Elsevier), and Editorial Board Member for a number of international journals including Journal of Food Process Engineering, Sensing and Instrumentation for Food Quality and Safety, Polish Journal of Food and Nutritional Sciences, etc. He is also a chartered engineer.

On May 28, 2010, he was awarded membership of the Royal Irish Academy (RIA), which is the highest honor that can be attained by scholars and scientists working in Ireland; and at the 51st CIGR General Assembly held during the CIGR World Congress in Quebec City, Canada on 13–17 June 2010, he was elected Incoming President of CIGR, and has become CIGR President (2013–2014)—the term of his CIGR presidency is six years, two years each serving as Incoming President, President, and Past President. On September 20, 2011, he was elected to Academia Europaea (The Academy of Europe), which is functioning as European Academy of Humanities, Letters, and Sciences and is one of the most prestigious academies in the world. Election to the Academia Europaea represents the highest academic distinction.

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### SECTIONI

# HIGH PRESSURE PROCESSING



# 1

# High-Pressure Processing of Foods: An Overview

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#### 1.1 INTRODUCTION

Food processing involves the transformation of raw animal or plant materials into consumer-ready products, with the objective of stabilizing food products by preventing or reducing negative changes in quality. Without these processes, we would neither be able to store food from time of plenty to time of need nor to transport food over long distances.

Nowadays, consumers are not only concerned about the sensory characteristics of food products (e.g., texture, flavor, aroma, shape, color, and aftertaste), they also pay more attention to their nutritional value. In general, consumers are demanding more minimally processed and additive-free food products. A goal of food manufacturers is to develop and employ processing technologies that retain or create the desired sensory and nutritional qualities, reduce undesirable changes in food due to processing, and extend the shelf life of food products.

There are a variety of preservation technologies that have been extensively used in the food industry, including physical (e.g., heating, freezing, chilling, dehydration, and packaging) and chemical (e.g., reduction of pH or use of preservatives) preservation methods. The basis of these traditional methods involves reducing microbial growth and metabolism to prevent undesirable chemical changes in food. Of the aforementioned preservation technologies, thermal treatment (e.g., pasteurization, sterilization) is probably the most commonly used. Although heating food effectively reduces levels of microorganisms, such processing can alter its natural taste and flavor, and can destroy its nutritional quality.

Therefore, alternative or novel food-processing technologies are being explored and implemented to provide safe, fresh-tasting, nutritive foods without the

using heat or chemical preservatives. Innovative nonthermal processes for preserving food have attracted the attention of many food manufacturers. In the search for new processing methods, particularly for certain products, the application of high-pressure (HP) processing has been regarded as a promising alternative to thermal treatments, in terms of ensuring safety and minimizing the processing effects on quality properties. Unlike heat treatment, proper HP treatment does not reduce the quality of foods, and pressure is evenly and instantaneously transmitted throughout the sample, which allows products without over-treated parts to be obtained. Moreover, HP technology has shown some potential for enhancing several food processes (e.g., extraction, freezing, thawing), as well as modifying the physicochemical properties of functional ingredients in some foodstuffs (Norton and Sun, 2008; Prasad et al., 2009; Tao et al., 2012).

#### 1.2 PRINCIPLES OF HP PROCESSING

Up to now, comprehensive research efforts have been directed toward understanding the effects of HP on various food products and food ingredients. In the meantime, a great number of works about using HP to process foods are still being performed. Some key findings in this regard will be summarized in this chapter.

#### 1.2.1 Background

Studies of the effects of HP on foods date back over a century; in 1899, Bert Hite from the Agriculture Research Station in Morgantown, West Virginia, designed and constructed a HP unit to pasteurize milk and other food products (Rivalain et al., 2010). In 1914, he showed that yeasts and lactic acid bacteria associated