CHAPTER 1

Emerging technologies in meat processing

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1.1 Context and challenges

Meat is a global product, which is traded between regions, countries and continents. The onus is on producers, manufacturers, transporters and retailers to ensure an ever-demanding consumer receives a top-quality product that is free from contamination. With such a dynamic product and market place, new innovative ways to process, package and assess meat products are being developed. In some instances, industry uptake of new technologies is stifled by a lack of knowledge about these new technologies and their impact on product quality and safety. With ever-increasing competition and tighter cost margins, industry has shown willingness to engage in seeking novel innovative ways of processing, packaging and assessing meat products while maintaining quality and safety attributes. Several new technologies have emerged with regard to meat processing, packaging and quality assessment, which have the potential to improve production efficiency while maintaining meat safety and quality. A number of novel thermal and non-thermal technologies designed to achieve microbial safety while minimising the effects on its nutritional and quality attributes have also become available.

Minimising changes in quality and safety during processing is a considerable challenge for food processors and technologists. Thus, there is a requirement for detailed industrially relevant information concerning emerging technologies in meat product manufacture. In addition, industrial adoption of novel processing techniques is in its infancy. Applications of new and innovative technologies and resulting effects to those food products either individually or in combination are always of great interest to academic, industrial, nutrition and health professionals.

1.2 Book objective

The primary objective of this book on *Emerging Technologies in Meat Processing* is to provide a comprehensive overview of the application of novel processing techniques as applied to the meat industry. The book evaluates recent advances on how meat is produced, processed and stored and is a benchmark reference book on novel processing, packaging and assessment methods of meat and meat products.

1.3 Book structure

Meat processors have a major responsibility to consumers when it comes to producing quality, nutritious and particularly safe foods. Conventional methods of meat processing and preservation (e.g. heat processing, low-temperature preservation or dehydration) have been used for hundreds of years. However, the last century has witnessed a dramatic increase in the development of new technologies, which have, in many cases, been hyped as replacements for conventional methods. However, in spite of much excitement relating to their discovery and potential, the anticipated uptake by industry has not occurred. In many cases, alternative technologies are still expensive in terms of capital outlay and are therefore not attractive options for processors, although they are generally becoming cheaper as time progresses. The reason for the lack of uptake most likely runs deeper than financial, as in many cases the alternatives are more economic or produce a higher quality product than conventional methods so that processors could recoup the initial capital outlay in reduced running costs or by charging higher prices for a premium quality product. It is most likely that the biggest obstacle these technologies face is a lack of basic understanding of their potential and, more importantly, when it comes to preservation, an unwillingness to trust the alternative methods compared to the tried and tested conventional methods. This book does not set out to try and convince food processors to drop conventional methods and replace them with alternatives. Instead, in Part 1, it sets to review alternative or novel processing techniques reinforcing the positive aspects of each operation and also discussing areas of weakness. Part 2 sets out an overview of alternative packaging solutions and meat functionality, clearly listing advantages and disadvantages and providing the reader with case studies where these technologies have been used. Part 3 reviews advances in assessment techniques for improved meat quality and safety.

Part 1 (processing techniques) consists of a number of chapters on novel processing techniques for the meat industry. Recent developments in irradiation, high-pressure processing, electroprocessing, light-based technologies, ultrasound, robotics and other emerging technologies are discussed with emphasis

on operational principles and inherent strengths and weaknesses of the technologies. In Chapter 2, the various sources of ionising radiation are described and distinguished. The mode of action is described and the advantages and disadvantages of irradiation are considered. The chapter finishes with a section outlining the author's view of the future for irradiation. Chapter 3 reviews the history of high preservation, and typical pressures used for meat preservation is put in context. The mode of action of high pressure in meat preservation is discussed, as are its advantages and disadvantages. While a lot has been published, more work needs to be done (e.g. pressure resistance problems, which can be overcome by combining pressure with either mild heat or cold) and the future for high pressure is considered in the final section of this chapter.

Electroprocessing has seen many technological developments in recent years. Chapter 4 begins with the classic categorisation of the different forms of electroheating in terms of the electromagnetic spectrum and then goes on to clearly describe and distinguish the heating mechanism of each. A central portion of the chapter is the presentation of case studies outlining situations where each of the electroheating technologies has been used to preserve products commercially or has undergone research and development to a form, which is suitable for commercial application. Chapter 5 focuses on the application of infrared and light-based technologies to meat and meat products. It has been suggested that magnetic UV, IR and high-intensity light pulses all have potential in meat preservation. Some forms are not always suitable for direct application but still have an important role to play in preservation as they can be used for applications such as sterilising packaging, contact surfaces or air within packaging equipment. These forms of electromagnetic radiation can be used in a number of forms (e.g. near vs far infrared) and the identification of where the various forms fit into the electromagnetic spectrum is achieved using a standardised electromagnetic spectrum diagram. This chapter explores the application, interactions and equipment associated with these light-based technologies in addition to illustrating practical case studies.

Chapter 6 begins where the fundamentals of ultrasonics are outlined and high-intensity versus low-intensity forms of ultrasound are distinguished. This is followed by a section in which ultrasonic equipment and specific industry-relevant case studies are discussed. The use of ultrasound for the decontamination of meat forms a central part of this chapter. It finishes with conclusions regarding the possible future for ultrasonics in meat preservation. Chapter 7 introduces the operational principles of emerging technologies such as the hydrodynamic shock wave, with particular emphasis on applications, mode of operation, advantages and disadvantages of the technology. The chapter concludes with some developmental advances in the technology. Part 1 of the book concludes with Chapter 8 which provides an overview of the use and application of robotics in meat processing. The chapter provides details for product handling and processing with emphasis on inherent strengths and

weaknesses. The chapter is illustrated by relevant case studies and provides a reference for currently available robotic equipment. The chapter finishes by providing a synopsis of the likely future role for robotics in meat processing.

Part 2 of the book deals with novel packaging and meat functionality. Recently the area of meat packaging has seen many new developments. This section reports on these developments and implications for shelf life, meat safety and quality. In particular, developments in novel packaging systems and smart packaging of meats are evaluated. Chapter 9 considers novel packaging solutions for meat products including the use of case-ready packaging with emphasis on modified atmospheric packaging and oxygen scavenging systems. The operational principles are detailed along with advantage and disadvantages of the technologies. The chapter concludes with a synopsis of the likely future role that novel packaging will play in the preservation of meat products. Packaging in the future is likely to be more than just a physical container that provides food with protection from the surrounding environment. Chapter 10 analyses the theory, mode of action and role of smart packaging systems in today's meat industry. The recent developments of nanotechnology in smart packaging systems are also discussed. In Chapter 11, the authors look at functionality in the meat product itself, with a focus on probiotics for meat products.

Rapid detection of pathogens and microbial contaminants is essential for ensuring meat quality and safety. Part 3 of this book looks at developments in rapid methods for microbial analysis. In addition, carcass evaluation technology and assessment of meat quality characteristics using computer vision and spectral techniques are evaluated. The section finishes with an assessment of meat authenticity.

Rapid detection of pathogens and microbial contaminants is essential for ensuring meat quality and safety and forms the basis of Chapter 12. Traditional detection methods have relied on time-consuming media culture methods with isolation. There have been a number of new innovations in methods for the microbiological analysis of meat. An array of rapid methods has been developed to make detection and identification faster, more convenient, more sensitive and more specific than conventional assays. This chapter assesses developments in this field and provide a synopsis of rapid methods of assessment. Chapter 13 focus on the use of hyperspectral techniques in evaluating quality and safety of meat and meat products. Spectral imaging techniques have emerged as techniques capable of detecting microbes in a non-destructive and rapid way. Case studies are reviewed and details on advantages and disadvantages of the technology are discussed.

Chapter 14 looks at carcass evaluation techniques with particular emphasis on in vivo methods (ultrasound, X-ray computed tomography (CT) and nuclear magnetic resonance (NMR)/magnetic resonance imaging (MRI)). Methods available for the prediction of body and carcass composition are evaluated. Methods for predicting composition of carcasses including video image analysis

(VIA), total body electrical conductivity (TOBEC) and bioelectrical impedance are discussed. Chapter 15 addresses the issue of meat authenticity. With an ever-expanding, open and globalised market place, meat products can be freely transported around the world. As illustrated in previous public health scares (e.g. dioxins in pork), consumer confidence in the meat industry is reliant on effective safety and authenticity. This chapter looks at recent developments in this field including the use of different authenticity techniques. The book concludes with Chapter 16 which provides an overview of the current role of food regulation practices within the European Union (EU) and internationally. International trade law, with emphasis on international food safety systems and food safety regulation within the EU, is discussed in addition to issues surrounding food marketing. The chapter concludes with a perspective on global trends and marketing challenges.

1.4 Conclusion

Emerging technologies do play an important role and have advantages for both processors and consumers. However, any likely uptake in the short term will be as part of a hurdle or minimal processing strategy in conjunction with conventional methods. The long-term success and uptake of emerging technologies depends on practicing food professionals receiving continued exposure to technological possibilities coupled with the education of new graduates of their potential. This text will serve as a comprehensive reference book for students, educators, researchers and food processors providing an up-to-date insight into emerging technologies for meat manufacture. The range of processes covered provides engineers and scientists working in the meat and food industries with a valuable resource for their work. Given the emphasis on novel technologies, the text is expected to have broad and significant appeal. This book can be a valuable reference book for companies, research institutions and universities active in the areas of meat processing, safety and quality evaluation.