Improving Food Quality with Novel Food Processing Technologies

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EDITED BY

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To my mother, Özden Tokuşoğlu, a retired teacher and to my father, Armağan Tokuşoğlu, a retired senior colonel, for their great emotional support and cordial encouragements.

Özlem Tokuşoğlu

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Editors

Özlem Tokuşoğlu, PhD, is an associate professor and faculty member of the Department of Food Engineering at Celal Bayar University, Manisa, Turkey. She earned a bachelor's degree (1992) and master's degree (1996) from Ege University, Izmir, Turkey in the Department of Chemistry and a PhD from Ege University in the Department of Food Engineering (2001). She worked as a researcher at Ege University from 1993 to 2001, and was a research associate in the Food Science and Nutrition Department at the University of Florida–Gainesville from 1999–2000. Dr. Tokuşoğlu was an assistant professor at Celal Bayar University, Manisa, Turkey, during 2002–2007.

Dr. Tokuşoğlu was a visiting professor in the Food Science and Nutrition Department at the University of Florida, Gainesville during 1999–2000 and at the School of Food Science, Washington State University, Pullman during April–May 2010. Her study focuses on food quality control, food chemistry, food safety and toxicology, shelf-life of foods, and innovative food processing technologies in foods, beverages, and functional products. Her specific study areas are phenolics, phytochemicals, bioactive antioxidative components, food additives, bioactive lipids, their determination by instrumental techniques, their effects on the quality of food and beverages, oil-fats and functional food technologies, and the novel food processing effects on food bioactives, food toxicants, and shelf-life of foods and beverages.

Tokuşoğlu has conducted academic research studies, delivered keynote addresses, and made academic presentations at Geneva, Switzerland in 1997; Gainesville, Florida, in 1999; Anaheim–Los Angeles, California, in 2002; Sarawak, Malaysia in 2002; Chicago, Illinois, in 2003; Szczyrk, Katowice, Poland in 2005; Ghent, Belgium in 2005; Madrid, Spain in 2006; New Orleans, Louisiana, in 2008; Athens, Greece in 2008; Anaheim–Los Angeles, California, in 2009; Skopje/Üsküp, the Republic of Macedonia in 2009, Chicago, Illinois, in 2010; Munich, Germany in 2010; Jamshoro, Sindh-Hyderabad, Pakistan in 2011; New Orleans, Louisana, in 2011; Boston, Massachusetts, in 2011; Natick, Massachusetts, in 2011; Damghan, Tehran, Iran in 2011; Osnabrück, Germany in 2011, Otsu, Kyoto, Japan in 2012; Chicago, Illinois, in 2013; Philadelphia, Pennsylvania, in 2013; Las Vegas, Nevada, in 2014; and San Francisco-Albany, California, in 2014. She has professional affiliations with the Institute of Food Technologists (IFT) and American Oil Chemists' Society (AOCS) in the United States and has a professional responsibility with the Turkey National Olive and Olive Oil Council (UZZK) as a research and consultative board member.

As conference chair, Professor Tokuşoğlu organized and directed the International Congress titled *ANPFT2012* (Advanced Nonthermal Processing in Food Technology: Effects on Quality and Shelf-Life of Food and Beverages) in May 7–10, 2012 at Kusadasi-Aegean, Turkey. She served as an organizing committee member at the 2nd International Conference and Exhibition on Nutritional Science & Therapy Conference in July 2013 in Philadelphia, USA and cochair at the *Food*

Technology 2014 conference (3rd International Conference and Exhibition on Food Processing and Technology) in July 2014 in Las Vegas, USA. She is currently chair of the Food Technology 2015 conference in August 10–12 in London, UK. Dr. Tokuşoğlu is an editorial board member of the *International Journal of Food Science and Technology* (*IJFST*) and the *Polish Journal of Food and Nutrition Sciences (PJFNS)*. Dr. Tokuşoğlu has several editorial and reviewer assignments in the Science Citation Index (SCI) and international index covered journals. She has published a scientific edited book titled *Fruit and Cereal Bioactives: Chemistry, Sources and Applications* by CRC Press, Taylor & Francis Group, and another book titled *Food By-Product Based Functional Food Powders* by CRC Press, Taylor & Francis Group, is in progress. She has published many research papers in peer-reviewed international journals, international book chapters, and international presentations (as oral and posters) presented at international congresses and other organizations. She was the principal administrator and advisor for the theses of four master's students, and currently one doctorate student and one master's student are under her supervision.

Barry G. Swanson, PhD, is Emeritus Regents Professor of the School of Food Science at Washington State University and the University of Idaho. Dr. Swanson's research interests range from studies of legume protein digestibility and storage quality in collaboration with the Institute for Nutrition in Central America and Panama (INCAP) supported by the USAID Collaborative Research Support Program (CRSP), to initial studies with sucrose fatty acid polyesters, syntheses of fat substitutes, alternative fat replacers and methods to improve the quality of reduced fat cheeses. More recent research interests focused on the implementation of ultra-high pressure to improve cheese yield and the hydrophobic functional properties of whey proteins. Dr. Swanson has coauthored more than 200 research manuscripts and 35 book chapters. He takes pride in having mentored 47 MS and 24 PhD students who now are successfully pursuing professional careers across the United States and around the world. Dr. Swanson received a College of Agricultural, Human, and Natural Resource Sciences (CAHNRS) Faculty Excellence in Research Award in 2001 and was invited to Michigan State University as a prestigious G. Malcolm Trout Visiting Scholar in 2004. In July 2005, he was recognized as one of ISI Thomson Citation Index's Most Highly Cited Researchers and is ranked 22nd among international authors in agricultural sciences, 1996–2006, by *Science Watch* 17(4), Thomson Scientific.

Dr. Swanson was elected a Fellow of IFT (Institute of Food Technologists) in 2002, and a Fellow of IUFoST (International Union of Food Science and Technology) in 2006. He is a retired editor of the *Journal of Food Processing and Preservation*. Dr. Swanson served for 6 years as executive secretary to the Washington State University (WSU) Faculty Senate, and served as interim director of the merged WSU and University of Idaho (UI) School of Food Science. He was promoted to the prestigious rank of Regents Professor at WSU and elected to the IFT Board of Directors in 2009. The professor retired in May 2011 and is currently serving on the IFT Education Advisory Panel and 2013 AMFE Food Chemistry Program Sub-Panel.

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Part I

Introduction

1 Introduction to Improving Food Quality by Novel Food Processing

Özlem Tokuşoğlu and Barry G. Swanson

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1.1 INTRODUCTION

Consumers around the world are better educated and more demanding in their identification and purchase of quality health-promoting foods. The food industry and regulatory agencies are searching for innovative technologies to provide safe and stable foods for their clientele. Thermal pasteurization and commercial sterilization of foods provide safe and nutritious foods that, unfortunately, are often heated beyond a safety factor that results in unacceptable quality and nutrient retention. Nonthermal processing technologies offer unprecedented opportunities and challenges for the food industry to market safe, high-quality health-promoting foods. The development of nonthermal processing technologies for food processing is providing an excellent balance between safety and minimal processing, between acceptable economic constraints and superior quality, and between unique approaches and traditional processing resources (Zhang et al., 2011). Nonthermal food processing is often perceived as an alternative to thermal food processing; yet, there are many nonthermal preparatory unit operations as well as food processing and preservation opportunities and challenges that require further investigation by the food industry. Nonthermal technologies are useful not only for inactivation of microorganisms and enzymes, but also to improve yield and development of ingredients and marketable foods with novel quality and nutritional characteristics (Bermudez-Aguirre and Barbosa-Canovas, 2011).

Nonthermal processing is effectively combined with thermal processing to provide improved food safety and quality. Nonthermal processing facilitates the development of innovative food products not previously envisioned. Niche markets for food products and processes will receive greater attention in future years.

Nonthermal technologies successfully decontaminate, pasteurize, and potentially pursue commercial sterilization of selected foods while retaining fresh-like quality and excellent nutrient retention. The quest for technologies to meet consumer expectations with optimum quality-safe processed foods is the most important priority for future food science research. Zhang et al. (2011) listed the relevant factors to consider when conducting research into novel nonthermal and thermal technologies such as: (1) target microorganisms to provide safety; (2) target enzymes to extend quality shelf life; (3) maximization of potential synergistic effects; (4) alteration of quality attributes; (5) engineering aspects; (6) conservation of energy and water; (7) potential for convenient scale-up of pilot-scale processes; (8) reliability and economics of technologies; and (9) consumer perception of the technologies. "The search for new approaches to processing foods should be driven, above all, to maximize safety, quality, convenience, costs, and consumer wellness" (Zhang et al., 2011).

Morris et al. (2007) conclude that nonthermal unit operations in food processing interest food scientists, manufacturers, and consumers because the technologies expose fresh foods to minimal impact on nutritional and sensory qualities, yet presumably provide safe shelf-stable foods by inactivating pathogenic microorganisms and spoilage enzymes. The presumption that nonthermal processing is energy efficient and environmentally friendly adds to contemporary popularity. Additional benefits to the food industry include the provision of food safety, value-added heat-labile foods, and new market opportunities.

Nonthermal food-processing technologies are extensive with high hydrostatic pressure (HHP), pulsed electric fields (PEFs), ultrasonics, ultraviolet light, ionizing irradiation (electron beams), and hurdle technologies leading the way. In addition, pulsed x-rays, pulsed high-intensity light, high-voltage arc discharge, magnetic fields, dense-phase carbon dioxide, plasma, ozone, chlorine dioxide, and electrolyzed water are receiving attention individually and as a hurdle in minimal processing protocols (Morris et al., 2007; Sun, 2005; Tokuşoğlu, 2012).

The authors in this book devote attention to improving food functionality with HHP and PEFs. The focus on improving the quality and retaining bioactive constituents of fruits and vegetables and improving the quality of dairy, egg, meat, and seafood products with HHP is evident in many chapters. The inclusion of modeling reviews and simulations of HHP inactivation of microorganisms and the relative effects of HHP processing on food allergies and intolerances broaden the scope of the information provided. Improving food functionality with PEF processes is focused on dairy and egg products, fruit juices, and wine. A chapter attending to industrial applications of HHP and PEF systems and potential commercial quality and shelf life of food products concludes this discussion.

HHP, ultra-high pressure (UHP), and ultra-high-pressure processing (HPP) are different names and acronyms for equivalent nonthermal processes employing pressures in the range of 200–1000 MPa with only small increases in processing temperature. The UHPs inactivate microbial cells by disrupting membrane systems, retaining the biological activity of quality, sensory, and nutrient cell constituents, thus extending the shelf lives of foods. High pressures inactivate enzymes by altering the secondary and tertiary structures of proteins, changing functional integrity, biological activity, and susceptibility to proteolysis. HHP processing of dairy proteins reduces the size of casein micelles, denatures whey proteins, increases calcium solubility, and induces color changes (Morris et al., 2007). The use of HHP to increase the yield of cheese curd from milk and accelerate the proteolytic ripening of Cheddar cheeses are promising improvements to the economics for the dairy food industry. The most widely available commercial applications of HHP include pasteurization of guacamole, tomato salsas, oysters, deli-sliced meats, and yogurts. The provision of HHP processing to provide a preservation method for thermally labile tropical fruits is very promising. It is stated that HHP provides pathogen inactivation, shelf-life extension, unwanted enzyme inactivation, gives innovative fresh products, reduced sodium products and clean-labelling (Figure 1.1a).

PEF processing exposes fluid foods to microsecond bursts of high-intensity electric fields, 10–100 kV/cm, inactivating selected microorganisms by electroporation, a disruption of cell membranes. PEF processing reliably results in five-log reduction in selected pathogenic microorganisms, resulting in minimal detrimental alterations in

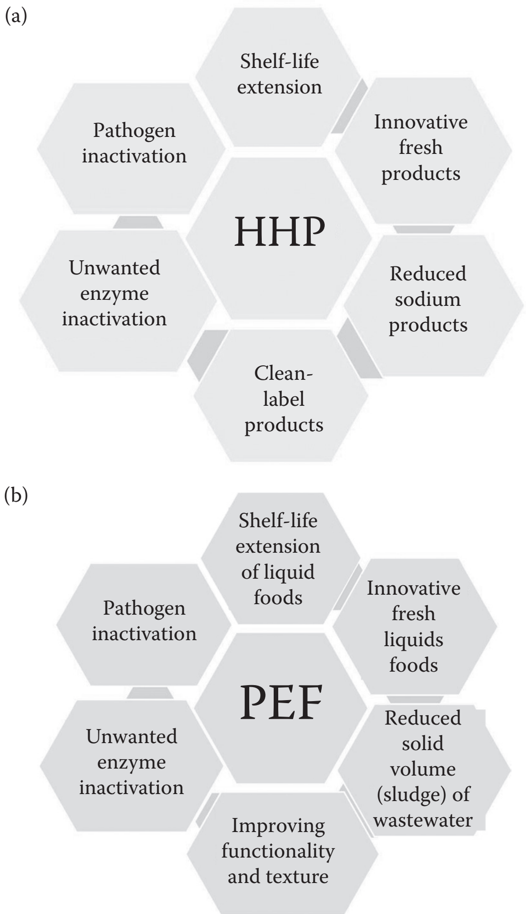

FIGURE 1.1 The usage area of HHP and PEF.

physical and sensory properties of the fluid foods. PEF adequately pasteurizes acid (pH < 4.5) fruit juices and research is continuing on uniform adequate pasteurization of milk and liquid eggs. The commercial application of PEF to improve the extraction yield of fruit juices and bioactive components of plant materials is in progress. PEF inactivation of enzymes is inconsistent and nonuniform, resulting in plant products subject to short shelf lives at ambient temperatures. It is expressed that PEF provides pathogen inactivation, shelf-life extension of liquid foods, unwanted enzyme inactivation, improves functionality and texture of foods, gives innovative fresh liquid foods and reduced solid volume (sludge) of wastewater (Figure 1.1b). Although PEF is identified as a nonthermal process, temperature increases during PEF processing result in fluid foods at 35–50°C, requiring cooling prior to packaging. The presence of particulates or bubbles in fluid foods subjected to PEF will result in dielectric breakdown, arcing, and scorching of the food. Homogenization and vacuum degassing are necessary to minimize the hazards associated with PEF processing of fluid foods. Technical issues that must be addressed to commercialize PEF for approval as an adequate food pasteurization technology include: (1) consistent and uniform generation of high-intensity electric fields; (2) identification of critical electric field intensities for uniform microbial inactivation; (3) identification of homogenization and vacuum-degassing techniques to assure the absence of particulates and air cells that promote arcing; and (4) identification of flow rates, temperature control, cooling, and aseptic packaging parameters to obtain processing uniformity and safe handling practices (Morris et al., 2007).

HHP and PEFs processing of foods continues with a focus on heat-labile acid fruits, vegetables, and dairy foods that meet consumer expectations for a minimally process, safety, fresh-like quality, and convenience. Nonthermal preservation extends shelf life without the addition of preservatives while retaining expected fresh-like appearance, sensory, and nutrient quality. It will be necessary to combine nonthermal and thermal preservation technologies to inactivate heat-resistant spores, potentially contaminating low-acid foods. Commercial nonthermal processing success stories such as pasteurized guacamole, oysters, salsa, yogurt, refrigerated meats, and improved yields of fruit juices, and bioactive compounds from herbs and other plant materials will demonstrate the efficacy and economic success of the technologies in niche markets. Successful research and identification of economic benefits, including energy and water conservation as well as demonstrated safety and fresh-like quality attributes will improve consumer perception of nonthermal technologies and result in further development by the food industry around the world.

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