processes

MDPI

Editorial

Special Issue "Recent Advances in Thermal Food Processing Technologies"

Ching Lik Hii [1,*], Choon Hui Tan [2] and Meng Wai Woo [3]

[1] Department of Chemical and Environmental Engineering, University of Nottingham Malaysia, Jalan Broga, Semenyih 43500, Selangor Darul Ehsan, Malaysia
[2] Department of Food Science and Nutrition, UCSI University Kuala Lumpur Campus, No. 1, Jalan Menara Gading, UCSI Heights (Taman Connaught), Kuala Lumpur 56000, Cheras, Malaysia
[3] Department of Chemical and Materials Engineering, Faculty of Engineering, University of Auckland, Auckland 1010, New Zealand
* Correspondence: ching-lik.hii@nottingham.edu.my

Historically, the application of thermal heating in food processing could be dated back to the invention by Nicholas Appert (1749–1841) which is nowadays known as canning and is able to preserve food products stored in glass bottles for an extended period. Later on, Louis Pasteur (1822–1895) investigated scientifically that food spoilage could be vastly reduced by destroying pathogenic microorganisms in food using the thermal treatment, and this resulted in better shelf life. As technology progresses, thermal food processing has since played a major role in the preservation, safety (microbial), and quality (nutritional) of food products [1].

Thermal food processing involves a wide range of unit operations which is not limited to pasteurization and sterilization, but also includes blanching, frying, baking, roasting, drying, evaporation, and so on. These processes can be operated in batch or continuous mode and under various sets of operating conditions (e.g., pressure, temperature, and time). Design of these unit operations requires knowledge from both science and engineering aspects of food processing.

Besides enhancement in food safety, the thermal processing of food also enhances product quality in many aspects. It can improve the digestibility of food by denaturation of protein as denatured proteins are more digestible as protein is unfolded and facilitate digestive enzymes to hydrolyse protein molecules [2]. The modification of the food matrix is mainly due to the breakdown of plant cell walls during thermal processing and thus improved the bioavailability of β-Carotene, lycopene, and lutein. Moreover, both caramelization and Maillard reaction are initiated during heat treatment that results in flavour and aroma developments, which further improve the palatability of food products [2]. Furthermore, thermal processing could improve the colour, texture, and functional properties of food products.

In terms of food safety, thermal processing is able to inactivate foodborne pathogens such as *Escherichia coli*, *Clostridium perfringens*, *Salmonella* species and *Staphylococcus aureus*. It is crucial to maintain microbial safety as it implies product shelf-life extension and eliminates food spoilage and food poisoning as well as other health concerns [3]. Other thermal processing methods such as dehydration and evaporation can reduce the water activity and moisture content of food products, therefore, the shelf-life can be further extended. Another benefit of thermal processing is the destruction of anti-nutritional factors, which are synthesized to protect seeds from environmental factors. One of the major concerns of anti-nutritional factors is the trypsin inhibitors as they may affect protein absorption capacity, and protein assimilation and lead to digestive complications. Therefore, thermal processing is crucial as it could destroy the trypsin inhibitors effectively.

However, thermal processing could also cause unintentional negative effects. Heat treatment may cause the loss of essential nutrients as it destroys heat-sensitive vitamins

Citation: Hii, C.L.; Tan, C.H.; Woo, M.W. Special Issue "Recent Advances in Thermal Food Processing Technologies". *Processes* **2023**, *11*, 288. https://doi.org/10.3390/pr11010288

Received: 10 January 2023
Accepted: 12 January 2023
Published: 16 January 2023

such as vitamins C, B1, B2, B6, and folic acid. Besides, it may also promote lipid oxidation and Maillard browning reaction that might reduce the nutritional value of food products. Furthermore, some thermal processing methods (e.g., microwave-assisted heating) might produce thermal food toxicants. There are hundreds of compounds formed during the Maillard reaction and lipid degradation, of which some have been identified as potentially carcinogenic and mutagenic. For example, heterocyclic aromatic amines, acrylamide, 5-hydroxymethylfurfural, furan, polycyclic aromatic hydrocarbons, nitrosamines, acrolein, chloropropanols, and chloroesters are examples of some frequently detected thermal food toxicants. Other adverse effect includes undesirable changes in the organoleptic quality of food product due to high-temperature heat treatment that further deteriorate the flavour, texture, and colour of food products [4].

As alluded to by the complexity described above, the design and operation of food thermal processes are not trivial. To that end, mathematical models can play a significant role to provide a guide. The core of most reported mathematical models of food thermal processes revolves around describing the transport phenomenon in the processes. Development of the model can, however, be approached from different length scales and complexities. The selection of a suitable length scale is certainly dependent on the purpose of the developed model. For example, if the interest was to optimize the energy or resource usage of the whole process, a process-wide mass, and energy balance, treating each operation unit as a lump, will be sufficient. While the development of such steady-state mass and energy balance may be routine engineering work, there is an increasing research interest in the development of more complex transient dynamics process-wide mass and energy balance.

Such a process-wide approach, however, does not describe much of what is happening within the thermal processing equipment. One-, two- and even three-dimensional models of the thermal processing equipment are then employed. There is a significant development in the modelling of food thermal processing at such a scale using the more detailed computational fluid dynamics (CFD) simulation technique. In a similar vein and transposed to a smaller scale, finite-element based models are also reported to describe food structural change during thermal processing. When using such well-developed simulation methods, there should be a significant emphasis on the development of sub-models which is embedded, and which transform these well-developed frameworks into specific food thermal processes. For example, what makes the CFD simulation of a spray dryer truly unique is the drying model developed and implemented into the framework. Along that line, there is significant interest in the development of models to describe the food thermal process at the smallest length scale. This can be the development of kinetic models to describe quality changes or other physicochemical phenomena involved. At this scale, the model development may require a strong component of fundamental experimental work. One should be mindful that such kinetics may require specialized experimental techniques and may not be obtainable from the actual commercial food thermal process.

Underpinning the multiscale approach described above, there is an increasing interest in the development of AI or computer-based learning models (black box models) in contrast to first principle-based models (white box models). With our reasonable physical and physicochemical understanding surrounding most food thermal processes, perhaps, the grey-box models (where white and black box models complement each other) may be the more reasonable approach to describe the more complex food thermal processes.

Author Contributions: Original draft preparation, C.L.H., C.H.T. and M.W.W.; review and editing, C.L.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Boekel, M.V.; Fogliano, V.; Pellegrini, N.; Stanton, C.; Scholz, G.; Lalljie, S.; Somoza, V.; Knorr, D.; Jasti, P.R.; Eisenbrand, G. A Review on the Beneficial Aspects of Food Processing. *Mol. Nutr. Food Res.* **2010**, *54*, 1215–1247. [CrossRef] [PubMed]
2. Zhang, Q.; Liu, R.; Geirsdóttir, M.; Li, S.; Tomasson, T.; Xiong, S.; Li, X.; Gudjónsdóttir, M. Thermal-induced Autolysis Enzymes Inactivation, Protein Degradation and Physical Properties of Sea Cucumber *Cucumaria frondosa*. *Processes* **2022**, *10*, 847. [CrossRef]
3. Demirok, N.T.; Yıkmış, S. Combined Effect of Ultrasound and Microwave Power in Tangerine Juice Processing: Bioactive Compounds, Amino Acids, Minerals and Pathogens. *Processes* **2022**, *10*, 2100. [CrossRef]
4. Tsai, C.F.; Jioe, I.P.J. The Analysis of Chlorogenic Acid and Caffeine Content and its Correlation with Coffee Bean Color under Different Roasting Degree and Sources of Coffee (*Coffea arabica* Typica). *Processes* **2021**, *9*, 2040. [CrossRef]