

Food Engineering Series

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Selected Topics in Food Process Engineering

Contents

1	Contributions of Food Engineering for the Transition Towards a Circular Economy. Opportunities, Challenges, and Limitations	1
	María del Pilar Buera, Cristina dos Santos-Ferreira, and Verónica Busch	
2	Food Science, Technology and Engineering Contributions and Challenges Dealing with Health, Environment, and Quality of Life	25
	Jorge Welte-Chanes, María S. Tapia, and Luis Eduardo Garcia-Amezquita	
3	Trends in Food Product Development	49
	Aureliano Rodríguez-Cortina, Diego H. Flórez-Martínez, Jader Rodríguez-Cortina, Óscar Álvarez, Martha L. Diaz-Bustamante, and María Hernández-Carrión	
4	Recent Developments and Innovations in Eco-Friendly UV Technologies for Ensuring Fruit Safety and Quality	73
	Paula L. Gómez, Paula Sol Pok, Gabriela Jaramillo-Sánchez, Stella M. Alzamora, Eunice V. Contigiani, Silvia M. Raffellini, and Héctor González	
5	High-Pressure Processing of Food: A Promise and a Reality	109
	Gustavo Víctor Barbosa-Cánovas, Manolya E. Oner, Kezban Candoğan, and Ga-Young Shin	

6	Integrating High-Energy Homogenization for the Preparation of Encapsulated Probiotic Bacteria	145
	Oscar O. Romero-Chapol, Abigail Varela-Pérez, Ana G. Castillo-Olmos, Claudia Figueroa-Hernández, Julieta del Carmen Villalobos-Espinosa, Hugo S. García-Galindo, and Cynthia Cano-Sarmiento	
7	Microbial Inactivation Using Hydrodynamic Cavitation	165
	Martínez-Monteagudo Sergio	
8	Solvent and Green Extraction Processes: Applications in the Food Industry	185
	Juan F. Osorio-Tobón, Julio Montañez, Oscar A. Vega-Castro, and Juan C. Osorio-Arias	
9	Molecularly Imprinted Polymers: An Emerging Strategy with Potential for Industrial-Scale Extraction in the Food and Wastewater Field	207
	Robinson Monsalve-Atencio, Diego Montañó-Montoya, and José Contreras-Calderón	
10	Towards the Industrial Application of Ionic Liquids as Green and Smart Extraction Media in the Food and Wastewater Field	255
	Robinson Monsalve-Atencio, Diego Montañó-Montoya, and José Contreras-Calderón	
11	Photoinactivation of Food Pathogens: Trends and Recent Developments	293
	Magda I. Pinzón-Fandiño, Leidy T. Sánchez, and Cristian Camilo Villa Zabala	
12	Digital Acoustic Signal Analysis During Breaking of Brittle Foods	307
	Carla Acosta-Ramírez, Evangelina García-Armenta, and Gustavo Fidel Gutiérrez-López	
13	Classical and Advanced Modeling of Convective Drying of Foods	323
	Rodolfo de Mattos and Berta Zecchi	
14	Changes in Fatty Acids and Sucrose of Coffee Beans During Thin-Layer Drying in a “Marquesina”- Type Solar Dryer: Experiments and Modeling	341
	Esteban Largo-Ávila, Víctor Hugo Borda-Yepes, David Alejandro Granados, Héctor José Ciro-Velásquez, and Farid Chejne	

15 Mathematical Modeling in Coffee Roasting: The Science Behind the Art	361
Jaime Daniel Bustos-Vanegas, Gentil Andrés Collazos-Escobar, Nelson Gutiérrez-Guzmán, and Tatiana Campos	
16 3D Food Printing: Fundamentals, Engineering Aspects and Applications	385
Kezban Candoğan, Pınar Kadioğlu-Şentürk, Gustavo Víctor Barbosa-Cánovas, Elvan Gökçen Topbaş, and Hilal Sena Hidiroğlu	
17 Application of Extracts and Emulsions in Active Film Technology	435
Jeannine Bonilla, Andresa Gomes, Camilo Agudelo-Cuartas, Diana M. Granda-Restrepo, and Paulo José do Amaral Sobral	
18 Nanotechnology: An Approach to Developing New Foods	475
Leidy Ricaurte and María Ximena Quintanilla-Carvajal	
19 Bioingredients: An Overview from Biotechnology and Bioeconomy	497
Fabian Hernández-Tenorio, Alex A. Sáez, David Ignacio Habeych-Narváez, Luz Deisy Marín-Palacio, and Catalina Giraldo-Estrada	
20 Seafood Peptides and Hydrolysates Produced by Emerging Technologies	517
Mario Pérez-Won, Carolina Herrera-Lavados, Luis González-Cavieres, and Gipsy Tabilo-Munizaga	
21 Wheat Grain Microstructure and Starch Digestion	547
Abhilasha Abhilasha, Lovedeep Kaur, and Jaspreet Singh	
22 Structuring Fat Analogues for the Manufacture of Meat Products: OSA Starch-Stabilized Emulsion Gels as a Potential Substitute	569
Robinson Monsalve-Atencio, Nelly Ospina de Barreneche, and José Contreras-Calderón	
23 Whey, a Problem with Multiple Solutions: L-Valine Production Through Fermentation	599
Darwin Carranza-Saavedra, Claudia Patricia Sánchez-Henao, and José Edgar Zapata-Montoya	
24 Production of Enzymatic Hydrolysates with Bioactive Potential, the Revalorization of Bovine Blood	613
Omar A. Figueroa and José Edgar Zapata-Montoya	
Index	627

Chapter 8

Solvent and Green Extraction Processes: Applications in the Food Industry



Juan F. Osorio-Tobón, Julio Montañez, Oscar A. Vega-Castro,
and Juan C. Osorio-Arias

1 Introduction

Consumers are increasingly aware of the impact of food on their health. Thus, foods with natural components are preferred over food with synthetic components. The demand for natural ingredients such as plant extracts is fast-growing globally. Plant extracts are known for their antioxidant and antibacterial activities due to the presence of bioactive metabolites. Plant extracts can be used in food as coloring agents, flavoring agents, preservative agents, functional ingredients, and edible oil. Thus, the recovery of bioactive metabolites for food matrices is a strategy widely used in the food and herbal medicinal sector and with a significant economic value (Jha & Sit, 2022). For example, according to the International Trade Centre (2022), plant extracts belong to a market estimated at USD 6.9 billion in 2020. Moreover, plant extracts can participate in the global functional food market, which is rapidly expanding and expect to grow up to 276.68 billion dollars at the end of 2024 with a compound annual growth rate of 9% (Lokhande & Pathak, 2021). Among the metabolites from plants, animals, microorganisms, and marine microorganisms with potential application in the food industry are carbohydrates, pigments, lipids, proteins, and amino acids. (Swamy & Akhtar, 2019). Moreover, the demand for

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bioactive compounds in different industries such as pharmaceuticals, food, nutraceuticals, cosmetics, and agricultural is growing, and the recovery of these compounds from plant and agro-industrial byproducts sources has been receiving significant attention. In that context, researchers are developing effective extraction processes under the approach of the Green Chemistry concept and its principles (Mohd Fuad et al., 2021).

The food industry needs to focus on greener and sustainable processes. For example, extraction is a crucial process before the purification of the bioactive compounds. In that context, the food industry is looking for greener extraction processes that use shorter extraction times and reduce the generation of toxic waste. Besides, there is great interest in adopting green extraction processes that require less energy and solvent in a sustainable approach. Thus, the use of green solvents that do not compromise the safety and quality of the extract is necessary (Makris, 2018). Green solvents are non-toxic, non-volatile, recyclable, biodegradable, and may not involve a high energy cost of synthesis (Torres-Valenzuela et al., 2020). Greener solvents such as supercritical fluids, ethanol, water, and natural deep eutectic solvents are increasingly used in the food industry.

Several conventional extraction processes such as maceration, Soxhlet, hydro-distillation, steam distillation, and percolation have been used to recover bioactive compounds from natural matrices. Although these extraction methods are energy and time-consuming, the use of GRAS (generally recognized as safe) solvents such as water or ethanol has improved the sustainability of these extraction processes. In the last decades, green novel extraction processes such as ultrasound-assisted extraction (UAE), supercritical fluid extraction (SFE), pressurized liquid extraction (PLE), ohmic heating extraction, and pulsed electric field extraction (PEF) have emerged. These novel extraction methods have been recognized for increasing extraction yield, reducing extraction times, and using environmentally friendly solvents (Putnik et al., 2019).

Diverse mechanisms and phenomena allow these extraction processes became a green alternative. For example, cavitation phenomena and implosion of cavitation bubbles enhance the extraction rates in UAE (Chemat et al., 2017). In SFE, a significant effect on solvent selectivity is caused by changes in pressure and temperature (Singh et al., 2021). In PLE, the elevated temperature enhances the solubility of the compounds while pressure keeps the solvent below its boiling point (Vazquez-Roig & Picó, 2015). In PEF, pores are formed into the cell membranes by an electric field. Then the membrane permeability is increased, enhancing the diffusion of the targeted compounds (Khadhraoui et al., 2021). In ohmic heating extraction (OHE), internal heat is generated by the application of electric fields on biological matrices (Bonifácio-Lopes et al., 2022). Moreover, these novel extraction processes allow the integration and intensification of the process. For example, ultrasound (Khadhraoui et al., 2021), pulsed electric fields (Aguilar-Machado et al., 2022; Ranjha et al., 2021), pressurized liquids (Viganó et al., 2022), and supercritical fluids (Al-Maqtari et al., 2021), have been used in the development of the integrated or intensified extraction processes. Figure 8.1 shows an overview of this chapter section, providing available information on conventional and novel