Innovative Food Science and Emerging Technologies 41 (2017) 357–377

Contents lists available at ScienceDirect

Innovative Food Science and Emerging Technologies

journal homepage: www.elsevier.com/locate/ifset

Review of Green Food Processing techniques. Preservation, transformation, and extraction

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ARTICLE INFO

Keywords:
Green Food Processing
Preservation
Transformation
Extraction
Innovative techniques
Intensification
Bio-refinery

ABSTRACT

This review presents innovative food processing techniques and their role in promoting sustainable food industry. These techniques (such as microwave, ultrasound, pulse electric field, instant controlled pressure drop, supercritical fluid processing) in the frontiers of food processing, food chemistry, and food microbiology, are not new and were already used for > 30 years by academia and industry. We will pay special attention to the strategies and the tools available to make preservation, transformation and extraction greener and present them as success stories for research, education and at industrial scale. The design of green and sustainable processes is currently a hot research topic in food industry. Herein we aimed to describe a multifaceted strategy (innovative technologies, process intensification, bio-refinery concept) to apply this concept at research, educational, and industrial level.

Industrial relevance: Green Food Processing could be a new concept to meet the challenges of the 21st century, to protect both the environment and consumers, and in the meantime enhance competition of industries to be more ecologic, economic and innovative. This green approach should be the result of a whole chain of values in both senses of the term: economic and responsible, starting from the production and harvesting of food raw materials, processes of preservation, transformation, and extraction together with formulation and marketing.

1. Introduction

Food products, such as fruit and vegetables, fat and oils, sugar, dairy, meat, coffee and cocoa, meal and flours, are complex mixtures of vitamins, sugars, proteins and lipids, fibres, aromas, pigments, antioxidants, and other organic and mineral compounds. Before such products can be commercialized, they have to be processed and preserved for food ready meals and extracted for food ingredients. Different methods can be used for this purpose, e.g. frying, drying, filtering, and cooking. Nevertheless, many food ingredients and products are well known to be thermally sensitive and vulnerable to chemical, physical and microbiological changes. Losses of some nutritional compounds, low production efficiency, time- and energy-consuming procedures (prolonged heating and stirring, use of large volumes of water…) may be encountered using these conventional food-processing methods. These shortcomings have led to the use of new sustainable "green and innovative" techniques in processing, pasteurization and extraction, which typically involve less time, water and energy, such as ultrasound-assisted processing, supercritical fluid extraction and processing, microwave processing, controlled pressure drop process, and pulse electric field. The tremendous efforts made on greening food process can be evaluated through the consideration of books and journals devoted to these aspects (Chemat, Huma, & Khan, 2011).

Food technology under extreme or non-classical conditions is currently a dynamically developing area in applied research and industry. Alternatives to conventional processing, preservation and extraction procedures may increase production efficiency and contribute to environmental preservation by reducing the use of water and solvents, elimination of wastewater, fossil energy and generation of hazardous substances. Within those constraints, "Green Food Processing" has to be introduced on the basis of green chemistry and green engineering: "*Green Food Processing is based on the discovery and design of technical processes which will reduce energy and water consumption, allows recycling of by-products through bio-refinery, and ensure a safe and high quality product*" (Fig. 1).

This review presents a complete picture of current knowledge on Green Food Processing techniques for preservation, transformation and extraction as success stories for research, education and at industrial scale. The readers like chemists, biochemists, chemical engineers,

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http://dx.doi.org/10.1016/j.ifset.2017.04.016
Received 16 November 2016; Received in revised form 23 February 2017; Accepted 30 April 2017
Available online 03 May 2017

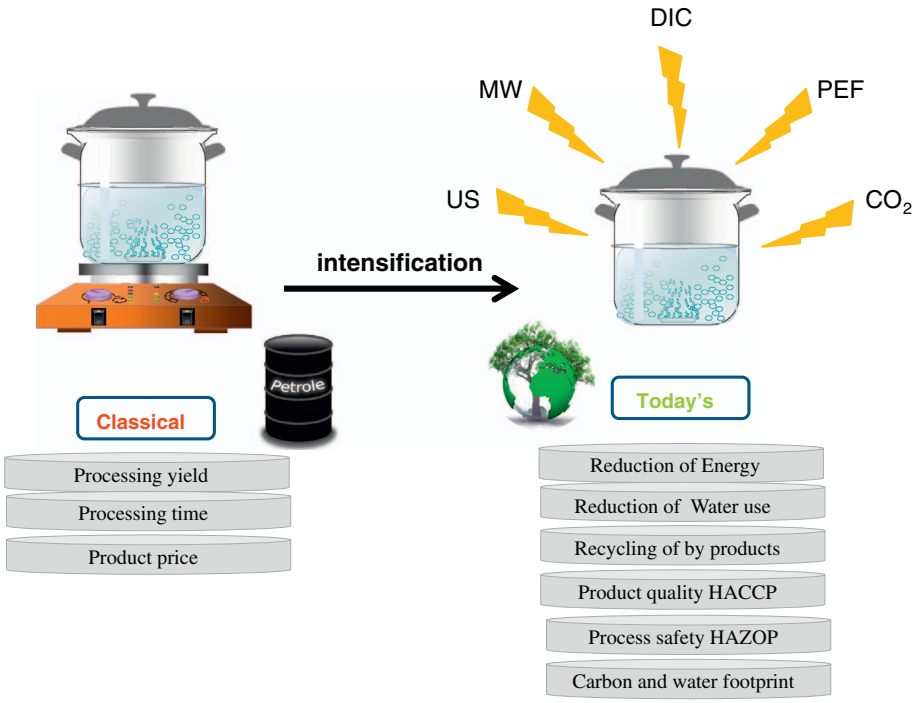

Fig. 1. Green Food Processing: evolution or revolution.

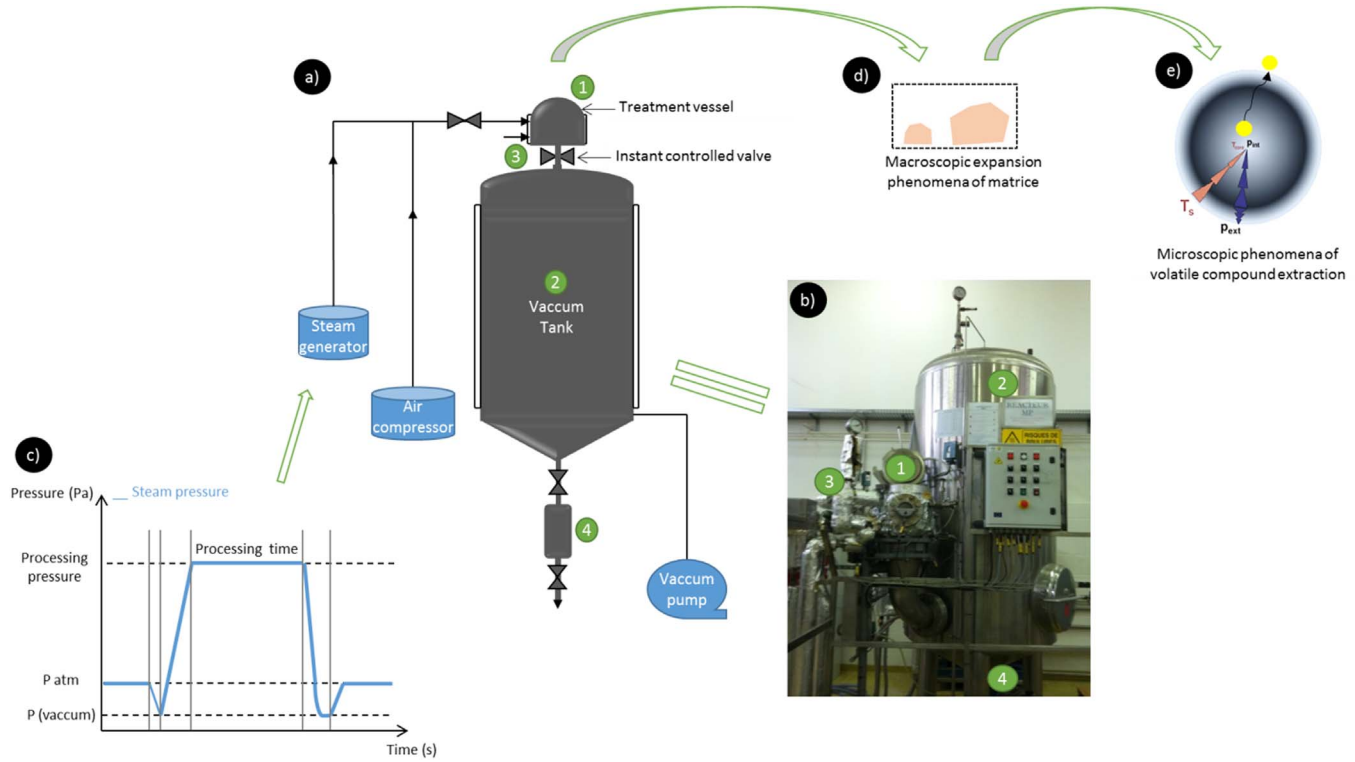

Fig. 2. Schematic representation (a) and photography (b) of DIC process, from experimental conditions (c) to an example of a major macroscopic (d) and microscopic (e) phenomena generated by DIC treatment.

physicians, and food technologists even from academia or industry will find the major solutions identified to design and demonstrate Green Food Processing on laboratory, classroom and industrial scale to approach an optimal consumption of raw food materials, water and energy: (1) improving and optimization of existing processes; (2) using non-dedicated equipment; and (3) innovation in processes and procedures.

2. Instant controlled pressure drop technology

2.1. Process and procedure

DIC 'Détente Instantanée Contrôlée', French for Instant Controlled Pressure-Drop is based on the main principle of the thermodynamics of instantaneity and auto-vaporization processing combining with hydro-