



# Handbook of waste management and co-product recovery in food processing

Volume 2

Edited by Keith Waldron

# **Handbook of waste management and co-product recovery in food processing**

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**Edited by  
Keith Waldron**



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# Preface

The global intensification of agriculture and food production has led to the creation of immense quantities of food co-products and wastes, often in centralised locations as food processors seek to achieve economies of scale. Typically, these wastes consist of biodegradable effluent and residues with high BOD and COD contents. Their uncontrolled spoilage and decomposition leads to the production of methane and other toxic moieties which are environmentally hazardous. In Europe alone, over 220 million tonnes of food-related waste are disposed of annually.

As a consequence of increased environmental awareness, the food industry is facing mounting legislative pressures such as the EU Council Directive 1999/31/EC on the landfill of waste to reduce food-processing and related wastes. Such pressures have contributed to an increase in costs of disposal and a reduction in landfill availability in many member states. Hence, methods to (a) reduce waste production, (b) valorise unused co-products, and (c) improve the management of unavoidable wastes, are becoming increasingly important to the food industry. Coincidentally, there is an increasing body of scientific literature relevant to exploiting food-processing co-products. However, much of it is published in scientific journals which do not focus specifically on this topic. This makes it more difficult for food technologists and industrialists to evaluate the 'state-of-the-art', and to exploit knowledge and expertise currently available.

It is in this context that the second volume of the *Handbook of waste management and co-product recovery in food processing* has been produced. This volume comprises further selected contributions from an array of internationally recognised experts who have reviewed the latest developments in this area. A particular emphasis has been put on assessing

environmental impact and addressing this issue through closed-loop approaches, and presenting overviews of recent developments in exploiting co-products in food and non-food areas. There are four main parts:

*Part I: Economic and legislative drivers for waste management and co-product recovery*

The scene is set in Chapter 1 which provides an overview of the key economic and legislative drivers that are promoting increased sustainability in the food chain. The opening chapter takes a holistic view of the concept of waste management and co-product recovery, evaluating the relative merits of activities in different parts of the 'waste hierarchy'. The chapter describes the use of 'value stream mapping' as a diagnostic technique, the purpose of which is to identify value-adding and non-value-adding activities in the value stream so that wasteful activities can be eliminated, and production aligned with demand. Chapter 2 focuses more specifically on the economics and cost-benefit of food waste co-product exploitation, drawing particularly on recent EU-funded multidisciplinary research in this area. Chapter 3 provides a comprehensive overview of the legislation relevant to co-product exploitation, again drawing on recent EU research, and highlights some of the key challenges such as novel-foods legislation.

*Part II: Environmental systems analysis and closed-loop factories*

Part II contains eight chapters that focus on environmental systems analysis (which measures the impact of process changes in the food industry) and approaches to reduce environmental impact through closed-loop approaches and recycling. The required changes in attitude to waste, which has been traditionally been considered in relation to disposal, are highlighted, and the concept of 'systems thinking' with a focus on life cycle assessment (LCA) is introduced in Chapter 4. The way in which changes to enhance one part of a process chain may impact on other parts in unforeseen ways is considered, and this leads into the design of food products in Chapter 5. Chapters 6 and 7 then explore closed-loop production in order to minimise waste and maximise efficiency (environmentally and economically) in food-processing systems. Chapters 8, 9 and 10 provide up-to-date reviews on how to improve the efficiency of water and energy use, and Chapter 11 explores the importance of sustainability in food packaging, again giving a whole-chain and systems perspective.

*Part III: Exploitation of co-products in food production*

Part III contains six chapters that explore approaches to exploit co-products in the production of food and feed ingredients. The opening chapter (12) describes the use of cell-wall degrading enzymes in disassembling fruit and vegetable-derived waste co-products, with emphasis on the use of pectinases. Chapter 13 evaluates a modular approach for processing fruit and vegetable wastes whilst Chapter 14 explores the biological conversion of

fruit and vegetable wastes using solid-state fermentation, with emphasis on the production of high-value volatile compounds. Chapter 15 provides a case-study of industrial exploitation of food-grade co-products in vegetable juice production, and the final two chapters in this part (16 and 17) provide definitive reviews on the exploitation of co-products in the production of animal and fish feeds.

*Part IV: Non-food exploitation of wastes and co-products*

One of the major difficulties associated with exploitation of co-products, and particularly where specific high-value components have been extracted, is the large quantity of relatively low-value residue that requires disposal. This is where the potential for exploitation in the non-food arena is crucial. The final part of Volume 2 provides a series of seven chapters that cover the non-food exploitation of food-chain wastes and co-products. Chapters 18 and 19 evaluate the potential for exploiting oil and carbohydrate-based wastes in the production of biofuels, and this is taken further in Chapter 20 which considers the concept of 'biorefining'. Chapters 21 and 22 concern the conversion of waste biomass into bioplastics and bioadsorbents, and Chapter 23 reviews the potential for recycling bone meal in crop production. The final chapter (24) of Volume 2 provides a comprehensive review of industrial composting and the broad range of uses of composted food processing co-products.

In summary, Volume 2 of *Handbook of waste management and co-product recovery in food processing* complements the recently published Volume 1, and demonstrates that the large body of research and development throughout the world is providing opportunities for innovation and wealth creation within an environmental context.

*Keith Waldron*

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