Flow Injection Analysis of Food Additives

Food Analysis & Properties

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Flow Injection Analysis of Food Additives **(2015)**
Edited by Claudia Ruiz-Capillas and Leo M.L. Nollet

Food Analysis & Properties Series

Flow Injection Analysis of Food Additives

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Series Preface

There will always be a need for analyzing methods of food compounds and properties. Current trends in analyzing methods are automation, increasing the speed of analyses, and miniaturization. The unit of detection has evolved over the years from micrograms to picograms.

A classical pathway of analysis is sampling, sample preparation, cleanup, derivatization, separation, and detection. At every step, researchers are working and developing new methodologies. A large number of papers are published every year on all facets of analysis. So there is need for books gathering information on one kind of analysis technique or on analysis methods of a specific group of food components.

The scope of the CRC series on Food Analysis and Properties aims at bringing out a range of books edited by distinguished scientists and researchers who have significant experience in scientific pursuits and critical analysis. This series is designed to provide state-of-the-art coverage on topics such as

1. Recent analysis techniques of a range of food components
2. Developments and evolutions in analysis techniques related to food
3. Recent trends in analysis techniques of specific food components and/or a group of related food components
4. The understanding of physical, chemical, and functional properties of foods

The book *Flow Injection Analysis of Food Additives* is the first volume of this series. I am happy to be a series editor of such books for the following reasons:

- I am able to pass on my experience in editing high-quality books related to food.
- I get to know colleagues from all over the world more personally.
- I continue to learn about interesting developments in food analysis.

A lot of work is involved in the preparation of a book. I have been assisted and supported by a number of people, all of whom I would like to thank. I would especially like to thank the team at CRC Press, with a special word of thanks to Steve Zollo, senior editor.

Many, many thanks to all the editors and authors of this volume and future volumes. I appreciate very much all their effort, time, and willingness to do a great job.

I dedicate this series to

- My wife, for her patience with me (and all the time I spent on my computer).
- All patients suffering from prostate cancer. Knowing what this means, I am hoping they will have some relief.

Leo M.L. Nollet

Foreword

Flow injection analysis is more than analytical technique. It is a platform for the majority of analytical methods.

G. D. Christian and A. Townshend

It is not by accident that the majority of the contributors to this outstanding monograph come from Spain. And it is not a coincidence that from 23 monographs published worldwide to date, the only ones that address the real-life applications of FIA, namely, *Flow Injection Analysis of Pharmaceuticals* (J. M. Clatayud), *Flow Injection Analysis of Marine Samples* (M. C. Yebra-Biurrun), and now *Flow Injection Analysis of Food Additives*, originate from Spain, where, 30 years ago, the pioneering work of M. Valcarcel and Luque de Castro laid the foundation for the acceptance of FIA as an important tool for chemical analysis.

While the discovery of a new analytical technique is exciting and self-rewarding, the real test of any novel technique is its acceptance by those who use it in real-life situations. And this is why the contribution of the Spanish research community is so important—it documents the applicability of the FIA technique in diverse fields of research and technology.

This monograph is truly unprecedented in its scope, both in terms of content and the breadth of the collective expertise. Its editors, Claudia Ruiz-Capillas and Leo M.L. Nollet, assembled a team of 80 authors from 14 countries to compose a work in 36 chapters of which the first six deal with FIA techniques, while the body of the work is focused on the ways in which a wide variety of samples and analytes can be assayed. The methods listed include preservatives, antioxidants, sweeteners, colorants, flavor enhancers, and other species. And this is where the lasting value of this exceptional book is to be found—in the detailed description of the amazing variety of underlying chemistries on which the individual assay protocols are based. As flow-based methodology and instrumentation evolve, their older versions are becoming obsolete; however, the chemistry of the underlying chemical reactions will remain the cornerstone on which the selective and sensitive assay protocols are based.

It must have been a Herculean task to orchestrate this multitude of talents spread across the globe and communicate in multiple languages. The editors are to be congratulated for bringing all these contributions to a successful conclusion and creating this work. I am sure that the result will be appreciated by many, not only in the current generation, but also in future generations of analytical chemists.

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Preface

During the past few years, the study of additives has become of great interest in different areas of research (nutrition, health, food technology, agricultural, etc.) worldwide. In the food industry, the use of additives is widespread, including a wide range of preservatives, antioxidants, sweeteners, colorants, flavor enhancers, emulsifiers, etc. Additives are used every day in the elaboration, processing, and conservation of food products for their different functions. The useful functions of these additives are important for maintaining food and beverage quality and characteristics that consumers demand, keeping food safe from farm to fork. However, some of these additives, such as nitrite and sulfite, present potential implications for human health. Therefore, the use of additives in foods and beverages is regulated by national and international authorities. The European Union and the U.S. Food and Drug Administration (FDA) have established a list of additives or a Food Additive Status List, respectively, according to their function. These agencies regulate additives in the manufacture of food products, assigning them an E number. This regulation tries to fix the levels of use so that these compounds fulfill a useful purpose (are effective) and at the same time are safe for the consumer. On the other hand, the European Food Safety Authority has established an acceptable daily intake (ADI) of different additives, fixing the amount that can be ingested without adverse effects on human health. In this sense, the levels of additives used should also be rigorously controlled and/or tested to maintain the characteristic of the foods to which they are added and to ensure consumer safety.

There are a number of methodologies for determining the different kinds of additives in foods and beverages, among them ion chromatography, gas chromatography, high-performance liquid chromatography, capillary electrophoresis, and enzymatic reactions. Most of these methods are expensive or less precise, or require complex instrumentation to work successfully, and this limits their use to the laboratory for routine analysis. However, among these existing methodologies, flow injection analysis (FIA) has many advantages, with great potential as an analytical methodology but also with some limitations and challenges. The FIA system was first described by Ruzicka and Hansen in 1975 and offers interesting advantages such as versatility, flexible accuracy, and suitability for a fast routine analysis of a large number of samples with high precision. Affordably priced and easy to use, it requires minimum intervention by the operator and lower consumption of samples and reactants. This is especially important when working with toxic or expensive reactants. It can be installed online and is compatible with a large number of detectors. This methodology responds to the growing demand for the mechanization and automation of analysis made by many laboratories faced with the challenge of the increasing number of routine analyses required. These advantages make FIA an important alternative to conventional methods for routine laboratory analysis, official institutions, and industry applications.

This book was proposed based on the importance of the determination of additives and the possible application of FIA for their determination. The objective of this book is to provide an overview/review of the possible applications of FIA as a useful tool for analyzing additives in foods and beverages. It is intended to be a compilation of useful FIA techniques as important alternatives to conventional methods in routine laboratory analysis.

No previous book has addressed both FIA and food additives. FIA is not a new topic, and there are some books on FIA, but these generally focus mainly on the theoretical basis and principles of FIA and on the design of equipment, instrumentation, manifold, setting mechanism, and so on. On the other hand, there are many books on food additives, but both these topics have been approached separately. However, the advantage of this book is the combination (link) of these two topics. This book aims to combine the analytical technique description itself and the direct application in the determination of food additives. It addresses the more important additives used in foods and beverages, and additives used every day in the food industry all over the world. This book provides the first review of measurements of additives and other substances by FIA in relation to the use of additives in food. It is intended to be an important manual for research, industry, and official administration laboratories.

This book consists of ten sections. The first section provides an introduction to the topic; reviews the origin of FIA, including recent developments and future trends. It discusses technical aspects of the study of SIA, miniaturization, and automation: nanotechnology; multicommutated FIA, and the combination of FIA and other analytical systems. The next six sections discuss the determination of additives. These sections are divided based on the official classification of additives according to function by the EU. Section II covers the study of preservatives with chapters on nitrates, nitrites, sulfites, sorbic acid and sorbates, benzoic acid, benzoates, parabens, acetic acid, acetates and lactic acid. Sections III and IV deal with the study of antioxidants; Section III with synthetic antioxidants (with chapters on BHT, BHA, TBHQ, propyl, octyl, dodecyl, gallates, phosphoric acid and phosphates, and lactates); and Section IV with natural antioxidants (with chapters on tartaric acid, ascorbic acid (vitamin C), vitamin E, phenolic compounds, flavonoids, and glutathione). Section V discusses sweeteners (with chapters on aspartame, sorbitol, acesulfame-K, cyclamate, and saccharin). Section VI discusses colorants and dyes (with chapters on riboflavin and quinoline and sunset yellow). Section VII discusses flavor enhancers (with chapters on monosodium glutamate, IMP, and GMP). Finally, in Sections VIII, IX, and X, the reader finds a review of the determination of antioxidant capacity (FRAP, ABTS, etc.), antimicrobial effects (TVBN, TMA, biogenic amines, etc.), and acidity by FIA, respectively. These determinations are not proper determinations of additives (with E numbers or without). However, these determinations are in relation to the use of additives in food (e.g., antioxidant or antimicrobial). These parameters or substances are very important in research and in the industry; some of them are used as quality control indices in food.

All chapters are organized in the same way: The first part begins with a small introduction in relation to the importance of the additive or compound in question in foods and beverages and discusses the legislation affecting their use and control. The second part focuses on the determination of the compound or additive by FIA in different foods or beverages, with sample preparation and extraction from a food/beverage on the one hand and FIA methods used for the separation and detection on the other.

We hope that the information in this book will be novel and will serve as a useful guide and reference source for research scientists in the food industry and other scientific

areas, academia, government, and official laboratories, as well as graduate and postgraduate students from various disciplines (veterinary medicine, chemistry, pharmacy, biology, food technology, etc.); regulatory agencies that use very affordable and easy-to-use technologies such as FIA; and those who are actively engaged in the analysis of foods and beverages to ensure both their safety and quality. Also, the book is meant for individuals interested in learning more about the determination of additives by FIA. In addition, we hope this book can help in the development of some of these methodologies.

The editors would like to thank all the contributors, who are well known in the world of FIA. They have collaborated to communicate their knowledge and experience to serve the readers of this book. We greatly appreciate their cooperation. We would also like to thank CRC Press, Taylor & Francis Group, for their encouragement and help in editing.

Claudia Ruiz-Capillas would like to thank Dr. Leo M.L. Nollet for granting her the opportunity to be his coeditor on this book and to share his extensive knowledge on this subject. Claudia would also like to thank Professors Jaromir Ruzicka and Elo Harald Hansen, who were the first authors of a publication on FIA. Professor Ruzicka encouraged Claudia all the time and agreed to write a foreword for this book; this was an honor. Thanks to F. Jiménez-Colmenero and A. M. Herrero for their advice and suggestions.

Finally, Claudia thanks her family, especially her mother, for her tolerance and time.

Claudia Ruiz-Capillas
Leo M.L. Nollet

Editors

Claudia Ruiz-Capillas earned her BSc degree from the Faculty of Veterinary Sciences of the Complutense University of Madrid (UCM), Spain and her MSc degree in food science (Faculty of Veterinary Sciences of the UCM). She has been working for several years on the production of biogenic amines and free amino acids in fish and meat products stored under different manufacturing and storage conditions. Dr. Ruiz-Capillas received her PhD degree in veterinary science from the UCM in 1997. She was a postdoc scholar (1997–1999) at the International Fisheries Institute in Hull University in the United Kingdom. The focus of her research was on flow injection analysis (FIA), and was done as part of the FAIR CT 96.3253 "QUALPOISS 2 project" (title: The Evaluation of a Simple, Cheap, Rapid Method of Non-Protein Nitrogen Determination in Fish Products through the Processing/Merchandising Chain). Presently, she is a research scientist at the Department of Products at the Meat and Meat Products Science and Technology Laboratory at the Institute of Food Science Technology and Nutrition (ICTAN-CSIC) of the Spanish Science Research Council (CSIC). Dr. Ruiz-Capillas's current research is focused on developing healthy meat products and improving their quality (reducing additives, biogenic amines, etc.). She has participated in various national and international research projects, taking the lead on some of them, and has more than 90 SCI scientific contributions in food science and technology to her credit. She has coauthored various chapters in published books, and is a guest editor of the *Special Issue Journal of Chemistry*. Dr. Ruiz-Capillas has supervised PhD theses and given lectures at conferences, seminars, courses, and master classes.

Leo M.L. Nollet earned his MS (1973) and PhD (1978) degrees in biology from the Katholieke Universiteit Leuven, Belgium.

Dr. Nollet is the editor and associate editor of a number of books. He edited the first, second, and third editions of *Food Analysis by HPLC* and *Handbook of Food Analysis* (Marcel Dekker, New York—now CRC Press, Taylor & Francis Group). The last edition of *Handbook of Food Analysis* is a two-volume book. He also edited *Handbook of Water Analysis* (first, second, and third editions) and *Chromatographic Analysis of the Environment*, 3rd edition (CRC Press).

He has coedited two books with F. Toldrá: *Advanced Technologies for Meat Processing* (CRC Press, 2006) and *Advances in Food Diagnostics* (Blackwell Publishing—now Wiley, 2007). He has coedited with M. Poschl the book *Radionuclide Concentrations in Foods and the Environment* (CRC Press, 2006).

He has coedited several books with Y. H. Hui and other colleagues: *Handbook of Food Product Manufacturing* (Wiley, 2007), *Handbook of Food Science, Technology and Engineering* (CRC Press, 2005), *Food Biochemistry and Food Processing* (first and

second editions; Blackwell Publishing–Wiley, 2006, 2012), and *Handbook of Fruit and Vegetable Flavors* (Wiley, 2010).

He edited *Handbook of Meat, Poultry and Seafood Quality* (first and second editions; Blackwell Publishing–Wiley, 2007, 2012).

From 2008 to 2011, he published with F. Toldrá five volumes in animal product–related books: *Handbook of Muscle Foods Analysis*, *Handbook of Processed Meats and Poultry Analysis*, *Handbook of Seafood and Seafood Products Analysis*, *Handbook of Dairy Foods Analysis*, and *Handbook of Analysis of Edible Animal By-Products*. Also with F. Toldrá, he coedited two volumes in 2011: *Safety Analysis of Foods of Animal Origin* and *Sensory Analysis of Foods of Animal Origin* (both from CRC Press). In 2012, they were coauthors of *Handbook of Analysis of Active Compounds in Functional Foods*, CRC Press.

He coedited with Hamir Rathore *Handbook of Pesticides: Methods of Pesticides Residues Analysis* (2009), *Pesticides: Evaluation of Environmental Pollution* (2012), and *Biopesticides Handbook* (2015), CRC Press.

His other completed book projects are *Food Allergens: Analysis, Instrumentation, and Methods* with A. van Hengel (CRC Press, 2011) and *Analysis of Endocrine Compounds in Food* (Wiley–Blackwell, 2011).

His recent projects are *Proteomics in Foods* with F. Toldrá (Springer, 2013) and *Transformation Products of Emerging Contaminants in the Environment: Analysis, Processes, Occurrence, Effects and Risks* with D. Lambropoulou (Wiley, 2014).

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