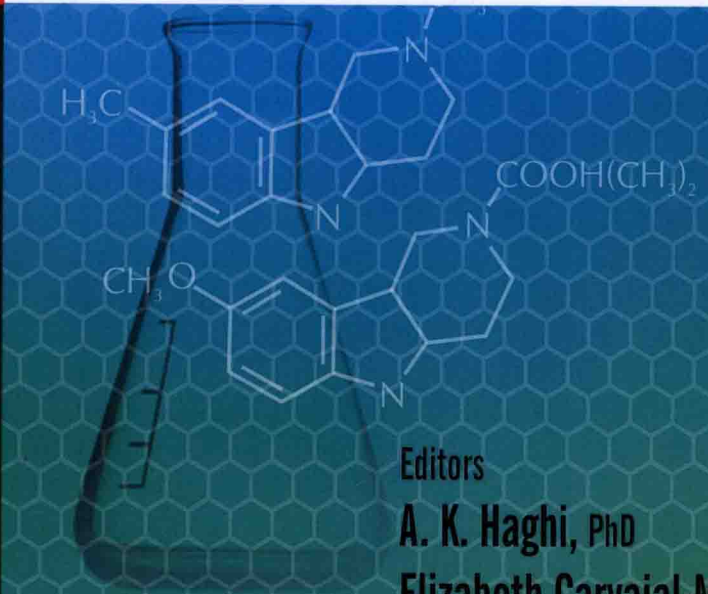
FOOD COMPOSITION and ANALYSIS

Methods and Strategies



Editors

A. K. Haghi, PhD

Elizabeth Carvajal-Millan, PhD

Apple Academic Press

CRC Press
Taylor & Francis Group

FOOD COMPOSITION AND ANALYSIS

Methods and Strategies

Edited by

A. K. Haghi, PhD, and Elizabeth Cervajal-Millan, PhD

Apple Academic Press

TORONTO NEW JERSEY

Apple Academic Press Inc.
3333 Mistwell Crescent
Oakville, ON L6L 0A2
Canada

Apple Academic Press Inc.
9 Spinnaker Way
Waretown, NJ 08758
USA

Printed in the United States of America on acid-free paper

International Standard Book Number-13: 978-1-926895-85-7 (Hardcover)

Library of Congress Control Number: 2014934523

Library and Archives Canada Cataloguing in Publication

Food composition and analysis: methods and strategies/edited by A.K. Haghi, PhD, and Elizabeth Carvajal-Millan, PhD.

Includes bibliographical references and index.
ISBN 978-1-926895-85-7 (bound)
1. Food--Composition. 2. Food--Composition--Methodology. 3. Food--Analysis. I. Haghi, A. K., editor of compilation II. Carvajal-Millan, Elizabeth, editor of compilation

TX541.F65 2014 664'.07 C2014-901332-9

Apple Academic Press also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic format. For information about Apple Academic Press products, visit our website at **www.appleacademicpress.com** and the CRC Press website at **www.crcpress.com**

FOOD COMPOSITION AND ANALYSIS

Methods and Strategies

ABOUT THE EDITORS

A. K. Haghi, PhD

A. K. Haghi, PhD, holds a BSc in urban and environmental engineering from the University of North Carolina (USA); a MSc in mechanical engineering from North Carolina A&T State University (USA); a DEA in applied mechanics, acoustics and materials from Université de Technologie de Compiègne (France); and a PhD in engineering sciences from Université de Franche-Comté (France). He is the author and editor of 65 books as well as 1000 published papers in various journals and conference proceedings. Dr. Haghi has received several grants, consulted for a number of major corporations, and is a frequent speaker to national and international audiences. Since 1983, he served as a professor at several universities. He is currently Editor-in-Chief of the *International Journal of Chemoinformatics and Chemical Engineering* and *Polymers Research Journal* and on the editorial boards of many international journals. He is a member of the Canadian Research and Development Center of Sciences and Cultures (CRDCSC), Montreal, Quebec, Canada.

Elizabeth Carvajal-Millan, PhD

Elizabeth Carvajal-Millan, PhD, has been working as a Research Scientist at the Research Center for Food and Development (CIAD) in Hermosillo, Mexico, since 2005. She obtained her PhD in France at Ecole Nationale Supérieure Agronomique de Montpellier (ENSAM), her MSc degree at CIAD, and undergraduate degree at the University of Sonora, Sonora, Mexico. Her research interests are focused on biopolymers, particularly in the extraction and characterization of polysaccharides of high value added co-products, recovered from the food industry, especially ferulated arabinoxylans. She has published more than 40 refereed papers, 15 chapters in books, over 60 conference presentations, and one patent.

LIST OF CONTRIBUTORS

M. Anachkov
Institute of Catalysis, Bulgarian Academy of Sciences, Sofia 1113, Bulgaria.

E. A. Averjanova
Sochi Branch of the Russian Geographical Society, 354024, Sochi, Kurortny pr., 113.
E-mail: geo@opensochi.org
Tel. +7 (8622) 619857

R. Badonia
Veraval Research Centre, Central Institute of Fisheries Technology, 362 029, Gujarat.

Vasudha Bansal
Agrionics Division (DU-1), Central Scientific Instruments Organisation (CSIO), CSIR
Chandigarh, India.

Mário C. J. Bier
Bioprocess Engineering and Biotechnology Department, Federal University of Paraná (UFPR), CEP 81531-990, Curitiba–PR, Brazil.

V.V. Borodai
Eco biotechnology and biodiversity department, Biotechnology faculty, National University of Life and Environmental Sciences of Ukraine, Kyiv 15, Geroiv Oborony str., Kyiv, Ukraine.
E-mail: veraboro@gmail.com

C. Bueno-Ferrer
Analytical Chemistry, Nutrition & Food Sciences Department, University of Alicante, P.O. Box 99, E-03080, Alicante, Spain.
Telephone: +34-965909660
E-mail: alfjimenez@ua.es

N. Burgos
Analytical Chemistry, Nutrition & Food Sciences Department, University of Alicante, P.O. Box 99, E-03080, Alicante, Spain.
Telephone: +34-965909660
E-mail: alfjimenez@ua.es

A. V. Bychkova
Federal state budgetary institution of science Emanuel Institute of Biochemical Physics of Russian Academy of Sciences, Kosygina str., 4, Moscow, 119334, Russia.
E-mail: annb0005@yandex.ru

Elizabeth Carvajal-Millán
Laboratory of Biopolymers, CTAOA. Research Center for Food and Development, CIAD, AC., Hermosillo, Sonora 83000, Mexico.
E-mail address: arascon@.ciad.mx

Cesar de Morais Coutinho
Department of Food Research - Campus of Frederico Westphalen – CAFW, Federal University of Santa Maria – RS.

Himani Dhanze
Research Scholar, Department of Veterinary Public Health, College of Veterinary & Animal Sciences, CSK-HPKV, Palampur-176062, Himachal Pradesh, India.

Karla Escarcega-Loya
Laboratory of Biotechnology, CTAOV, Research Center for Food and Development, CIAD, A.C., Hermosillo, Sonora 83000, Mexico.

Leifa Fan
Institute of Horticulture, Zhejiang Academy of Agricultural Sciences, 139 Shiqiao Road, Hangzhou-ZJ, P.R. China, 310021.

Sascha Habu
Federal University of Paraná, Dept. Bioprocess and Biotechnology. Rua Francisco H. dos Santos - Centro Politécnico, Jardim das Américas - Curitiba/Pr – Brazil.

E. A. Hassan
Department of Chemistry, Faculty of Science, AL-Azhar University, Cairo, Egypt.

A. Jiménez
Analytical Chemistry, Nutrition & Food Sciences Department, University of Alicante, P.O. Box 99, E-03080, Alicante, Spain.
Telephone: +34-965909660
E-mail: alfjimenez@ua.es

Porteen Kannan
Assistant Professor Department of Veterinary Public Health and Epidemiology, Madras Veterinary College, Chennai, India.

E. Chris Kazala
Department of Agricultural, Food & Nutritional Science, University of Alberta, 4-10 Agriculture/Forestry Centre, Edmonton, Alberta, Canada, T6G 2P5.

L. G. Kharuta
Sochi Institute of Russian people's friendship university, 354340, Sochi, Kuibyshev str., 32.
Fax +7 (8622) 411043
E-mail: sfrudn@rambler.ru

Paul P. Kolodziejczyk
Department of Agricultural, Food & Nutritional Science, University of Alberta, 4-10 Agriculture/Forestry Centre, Edmonton, Alberta, Canada, T6G 2P5.
Biolink Consultancy Inc., P.O. Box 430, New Denver, B.C., Canada, V0G 1S0.

E. I. Korotkova
Tomsk Polytechnic University, 30 Lenin Street, 634050, Tomsk, Russia
E-mail: eikor@mail.ru

A. L. Kovarski
Federal state budgetary institution of science Emanuel Institute of Biochemical Physics of Russian Academy of Sciences, Kosygina str., 4, Moscow, 119334, Russia.

V. B. Leonova
Federal state budgetary institution of science Emanuel Institute of Biochemical Physics of Russian Academy of Sciences, Kosygina str., 4, Moscow, 119334, Russia.

Y. López-Franco
Laboratory of Biopolymers, CTAOA, Research Center for Food and Development, CIAD, AC., Hermosillo, Sonora 83000, Mexico.

J. Lizardi-Mendoza
Laboratory of Biopolymers, CTAOA, Research Center for Food and Development, CIAD, AC., Hermosillo, Sonora 83000, Mexico.

B.G. Mane
Assistant Professor, Department of Livestock Products Technology.

A. L. Martínez-López
Laboratory of Biopolymers, CTAOA. Research Center for Food and Development, CIAD, AC., Hermosillo, Sonora 83000, Mexico.

Adriane B. P. Medeiros
Bioprocess Engineering and Biotechnology Department, Federal University of Paraná (UFPR), CEP 81531-990, Curitiba–PR, Brazil.

S. K. Mendiratta
Principal Scientist, Division of Livestock Products Technology, Indian Veterinary Research Institute, Izatnagar-243122, Uttar Pradesh, India.

V. M. Misin
Emanuel Institute of Biochemical Physics, Russian Academy of Sciences, 4 Kosygin Street, 119334 Moscow, Russia
E-mail: misin@sky.chph.ras.ru
E-mail: Natnik48s@yandex.ru

C.O. Mohan
Veraval Research Centre, Central Institute of Fisheries Technology, Gujarat 362 029.
E-mail: comohan@gmail.com

M. S. Mohy Eldin
Polymer Materials Research Department, Advanced Technology and New Materials Research Institute, City for Scientific Research and Technological Applications, New Boarg Elarab City, 21934, Alexandria, Egypt.

A Morales-Ortega
Research Center for Food and Development, CIAD, AC., Hermosillo, Sonora 83000, Mexico,

A. M. Omer
Polymer Materials Research Department, Advanced Technology and New Materials Research Institute,City for Scientific Research and Technological Applications, New Boarg Elarab City, 21934, Alexandria, Egypt.

A. E. Ordyan
Emanuel Institute of Biochemical Physics Russian Academy of Sciences, 4 Kosygin Street, 119334 Moscow, Russia.
E-mail: Natnik48s@yandex.ru

Xiao Qiu
Department of Food and Bioproduct Sciences, University of Saskatchewan, 51 Campus Drive, Saskatoon, Saskatchewan, Canada, S7N 5A8.

Nithya Quintoil
Teaching assistant Department of Veterinary Public Health and Epidemiology, Rajiv Gandhi Institute of Veterinary Education and Research, Puducherry, India.

S. Rakovsky
Institute of Catalysis, Bulgarian Academy of Sciences, Sofia 1113, Bulgaria.

Agustín Rascon-Chu
Laboratory of Biotechnology, CTAOV. Research Center for Food and Development, CIAD, AC., Hermosillo, Sonora 83000, Mexico.

C. N. Ravishankar
Fish Processing Division, Central Institute of Fisheries Technology, Cochin, 628 029.

S. Remya
Veraval Research Centre, Central Institute of Fisheries Technology, Gujarat 362 029.

M. A. Rosenfeld
Federal state budgetary institution of science Emanuel Institute of Biochemical Physics of Russian Academy of Sciences, Kosygina str., 4, Moscow 119334, Russia.

Suzan C. Rossi
Bioprocess Engineering and Biotechnology Department, Federal University of Paraná (UFPR), CEP 81531-990, Curitiba–PR, Brazil.

A. E. Rybalko
Sochi Institute of Russian people's friendship university, 354340, Sochi, Kuibyshev str., 32.
E-mail: sfrudn@rambler.ru
Fax +7 (8622) 411043

Alfonso Sánchez
Laboratory of Biotechnology, CTAOV. Research Center for Food and Development, CIAD, A.C., Hermosillo, Sonora 83000, Mexico

N. N. Sazhina
Emanuel Institute of Biochemical Physics, Russian Academy of Sciences
4 Kosygin Street., 119334 Moscow, Russia.
E-mail: misin@sky.chph.ras.ru
E-mail: Natnik48s@yandex.ru

Saleh Shah
Alberta Innovates-Technology Futures, P.O. Bag 4000, Vegreville, Alberta, Canada, T9C 1T4.

A. B. Sharangi
Department of Spices and Plantation Crops, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya (Agricultural University), Mohanpur, Nadia, WB (INDIA) ,Pin-741252
*Corresponding author: dr_absharangi@yahoo.co.in

Md. Wasim Siddiqui
Department of Food Science and Technology, Bihar Agricultural University, BAC, Sabour, Bhagalpur, Bihar (813210) India.

K. P. Skipina
Sochi Institute of Russian people's friendship university, 354340, Sochi, Kuibyshev str., 32.
E-mail: sfrudn@rambler.ru
Fax +7 (8622) 411043

Crystal L. Snyder
Department of Agricultural, Food & Nutritional Science, University of Alberta, 4-10 Agriculture/Forestry Centre, Edmonton, Alberta, Canada, T6G 2P5.

Carlos Ricardo Soccol
Bioprocess Engineering and Biotechnology Department, Federal University of Paraná (UFPR), CEP 81531-990, Curitiba–PR, Brazil.
Federal University of Paraná. Dept. Bioprocess and Biotechnology. Rua Francisco H. dos Santos - Centro Politécnico, Jardim das Américas - Curitiba/Pr – Brazil.

E. A. Soliman
Polymer Materials Research Department, Advanced Technology and New Materials Research Institute, City for Scientific Research and Technological Applications, New Boarg Elarab City, 21934, Alexandria, Egypt.

O. N. Sorokina
Federal state budgetary institution of science Emanuel Institute of Biochemical Physics of Russian Academy of Sciences, Kosygina str., 4, Moscow 119334, Russia.

T. K. Srinivasa Gopal
Central Institute of Fisheries Technology, Cochin, Kerala 628 029.

P Torres-Chavez
Department of Food Research & Graduate Program (DIPA), University of Sonora, Hermosillo, Sonora C.P. 83000, Mexico.

Luciana P. S. Vandenberghe
Bioprocess Engineering and Biotechnology Department, Federal University of Paraná (UFPR), CEP 81531-990, Curitiba–PR, Brazil.

Randall J. Weselake
Department of Agricultural, Food & Nutritional Science, University of Alberta, 4-10 Agriculture/Forestry Centre, Edmonton, Alberta, Canada, T6G 2P5.

G. E. Zaikov
N. M. Emanuel Institute of Biochemical Physics Russian Academy of Sciences, Moscow 119334, Russia.

LIST OF ABBREVIATIONS

ACL	Admissible concentration limit
AFLP	Amplified fragment length polymorphism
AO	Antioxidant
AOA	Antioxidant activity
AOPs	Advanced oxidation processes
AP	Active packaging
BAS	Biological active substances
CAT	Capillary agglutination test
CEPM	Continuous electrophoresis with porous membranes
CFUs	Colony forming units
CSNP	Chitosan nanoparticles
DDOS	Deodorized distillate of soybean oil
DM	Dry matter
DSC	Differential scanning calorimetry
EITB	Enzyme linked immunoelectro transfer blot
ELFA	Enzyme-linked fluorescent immunoassay
ELISA	Enzyme-linked immunosorbent assay
ES	Electrical stimulations
FDA	Food and drug administration
FTIR	Fourier-transform infrared spectroscopy
GAC	Granular activated carbon
GC/FID	Gas chromatography with flame-ionization detection
GC/MS	Gas chromatography-mass spectrometry
GFSE	Grapefruit seed extract
GHP	Good hygienic practices
GRAS	Generally recognized-as-safe
HACCP	Hazard analysis of critical control points
HOC	Halogenated organic compounds
HPLC	High-performance liquid chromatography
HS	Hard segments
HTC	Hard-to-cook
ICGFI	International consultative group on food irradiation
IFA	Immunofluorescence assay
INIFAP	Investigation in forestry, agriculture, and animal production
LA	Latex agglutination
LAPS	Light-addressable potentiometric sensors
MAP	Modified atmosphere packaging
MBE	Molecular beam epitaxy

MDSC	Modulated differential scanning calorimetry
MFE	Mercury film electrode
MFI	Myofibrillar Fragmentation Index
MNPs	Magnetic nanoparticles
MWCO	Molecular weight cut off
PACs	Polycyclic aromatic compounds
PCR	Polymerase chain reaction
PTM	Transmembrane pressure
RBPT	Rose Bengal plate test
ROS	Reactive oxygen species
RPLA	Reverse passive latex agglutination
SEM	Scanning electron microscope
SEM	Scanning electron microscopy
SET	Staphylococcal enterotoxin
TAA	Total antioxidant activity
TEAC	Trolox equivalent antioxidant capacity
TGA	Thermogravimetric Analysis
UV	Ultraviolet
VLSI	Very large scale integration
WEAX	Water extractable arabinoxylans
WHO	World Health Organization
WPI	Whey protein isolate

PREFACE

Many foods depend on additives for safety and stability or preservation. Foods are packaged to protect them and keep them in good condition while they are delivered to shops, stacked on shelves, or stored at home. This is a comprehensive advanced level book that provides thorough up-to-date coverage of a broad range of topics in food science and technology and describes avenues of advanced study in the field. The book explores key food commodities and food composition with an emphasis on the functional properties of each commodity.

The so-called HACCP (Hazard Analysis and Critical Control Points) acronym is well known in the food industry in relation to the management of microbiological, chemical, and physical risks. This book is designed to help current and prospective researchers in this field.

This volume introduces and surveys the broad and complex interrelationships among food ingredients and processing, and explores how these factors influence food quality and safety. The book in food science is also a valuable reference for professionals in food processing, as well as for those working in fields that service, regulate, or otherwise interface with the food industry.

This book is divided into 21 chapters:

Thermoplastic polyurethanes bio-based TPUs were synthesized in chapter 1 from a di-functional dimmer fatty acid-based polyol obtained from rapeseed oil, MDI, and BDO at four HS a content that is 10–40 wt%. The polyol characteristics determined the structure and properties of TPUs. The FTIR-ATR spectra confirmed that all the isocyanate groups reacted with hydroxyl groups (from polyol or BDO) during the TPUs synthesis. Thermal studies carried out by TGA, DSC, and MDSC revealed some interactions between hard and soft domains for all TPUs and a degradation behavior closely linked to their HS concentration. Stress-strain uniaxial tests showed that the increase in HS content in TPUs lead to higher tensile modulus and lower elongation at break. The TPU10 and TPU20 showed a strong elastomeric behavior with very high elongation at break (>600%) and very low elastic modulus.

In summary, TPUs partially synthesized from vegetable oils are very promising materials in good agreement with the current tendency for sustainable development, making them very attractive since they are expected to show specific properties which can be easily tailored by selecting the appropriate HS concentration. These materials could also fulfill many industrial requirements for different fields, such as construction, automotive, textile, adhesive, and coatings.

In chapter 2 antioxidant activity of maize bran arabinoxylan micro-spheres were introduced. The comparative analysis of measurements of the total antioxidants content and their activity for juice of 34 different kinds of Kalanchoe (*Kalanchoe* L.) is carried out by two methods in chapter 3: ammetric and chemiluminescence. Results of

measurement show good (89%) correlation. Among the studied samples, the two most active kinds of Kalanchoe are exposed: *K. scapigera* and *K. rhombopilosa*. They can appear to be more prospective sources of biologically active components in comparison with kinds which are used now. In chapter 4 it is shown that new applications of enzymes within the food industry will depend of the functional understanding of different enzyme classes. Furthermore, the scientific advances in genome research and their exploitation via biotechnology is leading to a technology driven revolution that will have advantages for the consumer and food industry alike. In chapter 5, it is shown that the membranes are among the most important industrial applications today, and every year, more indications are found for this technology, such as water purification, industrial wastewater treatment, dehydration solvent recovery of volatile organic compounds, protein concentration, and many others.

In chapter 6, the various aspects of meat tenderness—such as process of tenderness of meat, practices of meat tenderness, influences of various conditions on meat tenderness, methods of tenderization of meat and meat products and physicochemical determinants of meat tenderness—are discussed. Biological properties of mushrooms are investigated in chapter 7. Molecular and immunological approaches for the detection of important pathogens in foods of animal origin are investigated in chapter 8.

In chapter 9, Cross-Linking of Ferulated Arabinoxylans Extracted from Mexican Wheat Flour: Rheology and Microstructure of the Gel is presented. Free and ester-linked ferulic acid content in a hard-to-cook pinto bean (*Phaseolus vulgaris* L.) variety is discussed in chapter 10. Chapter 11 discusses polyacrylamide-grafted gelatin: swellable hydrogel delivery system for agricultural applications in detail. The dynamics of bacteria and pathogenic fungi in soil microbiocenosis under the influence of biopreparations used during potato cultivation is introduced in chapter 12.

In chapter 13, the safety of irradiation has been clearly accepted as effective technology, and regulatory authority has been established on a global basis. Consumers' choice is the final preference for taking the technology to the market. In coming years, irradiation will empower the existing processing technologies. Irradiation is therefore providing safety and health as well as minimizing the losses on a large front and emerging as economical processing as well. Antioxidant properties of various alcohol drinks are studied in chapter 14. A study on the potential of oilseeds as a sustainable source of oil and protein for aquaculture feed is presented in chapter 15. Electrochemical methods for estimation of antioxidant activity of various biological objects are investigated in chapter 16. Ozonolysis of chemical and biochemical compounds are reviewed in chapter 17. Antioxidant activity of mint is explained in chapter 18. Wild orchids of Colchis forests to save them as objects of eco education and as producers of medicinal substances are introduced in chapter 19. Chapter 20 is about the fixation of proteins on MNPs, and chapter 21 studies the antimicrobial packaging for food applications.

— A. K. Haghi, PhD, and Elizabeth Carvajal-Millan, PhD

CONTENTS

CHAPTER 1

VEGETABLE OILS AS PLATFORM CHEMICALS FOR SYNTHESIS OF THERMOPLASTIC BIO-BASED POLYURETHANES

C. BUENO-FERRER, N. BURGOS, and A. JIMÉNEZ

CONTENTS