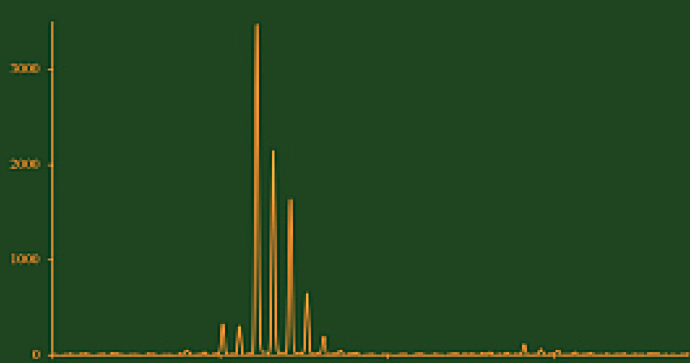
Recent Advances in Polyphenol Research

Volume 7

Edited By

Jess Reed,
Victor de Freitas,
and Stéphane Quideau



WILEY Blackwell

Table of Contents

List of Tables

List of Illustrations

Chapter 8

Recent Advances in Polyphenol Research

A series for researchers and graduate students whose work is related to plant phenolics and polyphenols, as well as for individuals representing governments and industries with interest in this field. Each volume in this biennial series focuses on several important research topics in plant phenols and polyphenols, including chemistry, biosynthesis, metabolic engineering, ecology, physiology, food, nutrition, and health.

Ann E. Hagerman (Miami University, Oxford, Ohio, USA)
Heidi Halbwirth (Vienna University of Technology, Austria)
Amy Howell (Rutgers University, Chatsworth, New Jersey, USA)
Johanna Lampe (Fred Hutchinson Cancer Research Center, Seattle, USA)
Vincenzo Lattanzio (University of Foggia, Italy)
Stephan Martens (Fondazione Edmund Mach, IASMA, San Michele all'Adige, Italy)
Nuno Mateus (University of Porto, Portugal)
Fulvio Mattivi (University of Trento, Italy)
Jess Dreher Reed (University of Wisconsin–Madison, USA)
Annalisa Romani (University of Florence, Italy)
Erika Salas (Autonomous University of Chihuahua, Chihuahua, Mexico)
Juha-Pekka Salminen (University of Turku, Finland)
Pascale Sarni-Manchado (INRA, Montpellier, France)
Celestino Santos-Buelga (University of Salamanca, Spain)
Kathy Schwinn (Plant & Food Research, Palmerston North, New Zealand)
Karl Stich (Vienna University of Technology, Austria)
David Vauzour (University of East Anglia, Norwich, UK)
Kristiina Wähälä (University of Helsinki, Finland)
Kumi Yoshida (Nagoya University, Japan)

Recent Advances in Polyphenol Research

Volume 7

Edited by

Jess Dreher Reed
Professor, Nutrition and Phytochemistry
Department of Animal Sciences, College of Agricultural and Life Sciences
University of Wisconsin–Madison, Madison, USA
Complete Phytochemical Solutions LLC, Cambridge, Wisconsin, USA

Victor Armando Pereira de Freitas
Professor, Food Chemistry
Chemistry and Biochemistry Department, Faculty of Sciences
University of Porto, Porto, Portugal

Stéphane Quideau
Professor, Organic and Bio-organic Chemistry
Institut des Sciences Moléculaires, CNRS-UMR 5255
University of Bordeaux, Talence, France & Institut Universitaire de France, Paris, France

WILEY Blackwell

This edition first published 2021

Registered Office(s)
John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, USA
John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial Office
The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

For details of our global editorial offices, customer services, and more information about Wiley products visit us at www.wiley.com.

Wiley also publishes its books in a variety of electronic formats and by print-on-demand. Some content that appears in standard print versions of this book may not be available in other formats.

Library of Congress Cataloging-in-Publication data applied for

ISBN: 9781119545927
ISSN: 2474-7696

Cover Design: Wiley
Cover Images: © Reed Research Group

Contributors

Nick W. Albert
Plant & Food Research, Palmerston North, New Zealand

C. Peter Constabel
Centre for Forest Biology and Biology Department, University of Victoria, Victoria, Canada

Kevin M. Davies
Plant & Food Research, Palmerston North, New Zealand

Kriya Dunlap
Department of Biochemistry, University of Alaska Fairbanks, Fairbanks, USA

Daniel Esquivel-Alvarado
Department of Animal Sciences, University of Wisconsin–Madison, Madison, USA

Ana Gutiérrez
Instituto de Recursos Naturales y Agrobiología de Sevilla (IRNAS), CSIC, Seville, Spain

Rubina Jibran
Plant & Food Research, Palmerston North, New Zealand

James A. Kennedy
Functional Phenolics, LLC, Corvallis, USA

Christian G. Krueger
Complete Phytochemical Solutions LLC, Cambridge, Wisconsin, USA
Department of Animal Sciences, University of Wisconsin–Madison, Madison, USA

Hoon Kim
Department of Energy Great Lakes Bioenergy Research

Center, Wisconsin Energy Institute
University of Wisconsin–Madison, Madison, USA

Wu Lan
Department of Biological System Engineering
University of Wisconsin–Madison, Madison, USA &
Department of Energy Great Lakes Bioenergy Research
Center, Wisconsin Energy Institute
University of Wisconsin–Madison, Madison, USA

Mary Ann Lila
Department of Food Bioprocessing and Nutrition Sciences,
Plants for Human Health Institute, North Carolina State
University, Kannapolis, USA

Richard L. Lindroth
Department of Entomology, University of Wisconsin–
Madison, Madison, USA

Dawei Ma
Centre for Forest Biology and Biology Department,
University of Victoria, Victoria, Canada

Johan Mendoza
Department of Chemistry, Nova School of Science and
Technology, Caparica
Portugal

Irene Mueller-Harvey
School of Agriculture, Policy and Development, University
of Reading, Reading, UK

Ken Ohmori
Department of Chemistry, Tokyo Institute of Technology,
Tokyo, Japan

Marisa S. Otegui
Department of Botany, University of Wisconsin–Madison,
Madison, USA

Fernando Pina
Department of Chemistry, Nova School of Science and Technology, Caparica, Portugal

John Ralph
Department of Energy Great Lakes Bioenergy Research Center, Wisconsin Energy Institute, University of Wisconsin–Madison, Madison, USA & Department of Biochemistry, University of Wisconsin–Madison, Madison, USA

Jess Dreher Reed
Department of Animal Sciences, University of Wisconsin–Madison, Madison, USAComplete Phytochemical Solutions LLC, Cambridge, Wisconsin, USA

Jorge Rencoret
Instituto de Recursos Naturales y Agrobiología de Sevilla (IRNAS), CSIC, Seville, Spain

José C. del Río
Instituto de Recursos Naturales y Agrobiología de Sevilla (IRNAS), CSIC, Seville, Spain

Kennedy F. Rubert-Nason
Division of Natural and Behavioral Sciences University of Maine–Fort Kent, Fort Kent, USA

Kathy E. Schwinn
Plant & Food Research, Palmerston North, New Zealand

Keisuke Suzuki
Department of Chemistry, Tokyo Institute of Technology, Tokyo, Japan

Wayne E. Zeller
ARS-USDA, U.S. Dairy Forage Research Center, Madison, USA

Yanfei Zhou
Plant & Food Research, Palmerston North, New Zealand

Preface

Every two years, Groupe Polyphénols (GP) hosts the International Conference on Polyphenols (ICP). The XXIX ICP was the first one to be held in the United States in Madison, Wisconsin, on the campus of the University of Wisconsin–Madison (UW–Madison), from July 16 to 20, 2018. Groupe Polyphénols also hosted the 9th Tannin Conference (TC) concurrently with the XXIX ICP. Groupe Polyphénols was founded in 1972 and is the world's premier society of scientists in the fields of polyphenol chemistry, synthesis, bioactivity, nutrition, industrial applications, and ecology.

Madison is Wisconsin's state capital (the capitol building is shown on the front cover) and one of the nicest cities in the great lakes region. UW–Madison is a top ranked University (25th worldwide and 19th in the USA) and has a lovely campus with miles of lakefront and beautiful scenery adjacent to the state capitol. This venue for the XXIX ICP and 9th TC was fitting because Wisconsin's cranberry industry provides 60 percent of the world's supply of cranberries and is the state's largest fruit industry. The cranberry industry is also strongly dependent on the polyphenolic composition of the fruit. Cranberries are harvested in the fall after they turn from yellow-green to bright red, as shown on the front cover. The fruits are harvested by flooding the marsh (also called cranberry bogs). After removing the fruits from the vine, they float to the surface and are corralled with a floating boom and conveyed into trucks (as depicted on the front cover). The fruits are either transferred to a packaging facility for the fresh fruit market or to a frozen storage facility for subsequent processing into juice or sweetened dried cranberries (SDC). In both cases the bright red color of the fruit is a critical component of processing because the fruit is sorted based on color before packaging as fresh fruit or processing for juice and SDC (a processing line after sorting is also shown on the front cover). The color is a function of six anthocyanins, cyanidin 3-O-galactoside, cyanidin 3-O-glucoside, cyanidin 3-O-arabinoside, peonidin 3-O-galactoside, peonidin 3-O-glucoside, and peonidin 3-O-arabinoside. In addition to the anthocyanins, cranberries contain a large diversity of other monomeric polyphenols, especially flavonol glycosides, and contain simple phenols such as hydroxycinnamic acids and hydroxybenzoic acids. Cranberries also contain proanthocyanidins, which are just as important to the economic value of the fruit as the anthocyanins. The importance of proanthocyanidins to the cranberry market is a result of pioneering research from the late 1990s in which "A-type" interflavan bonds were discovered to be the structural feature of cranberry proanthocyanidins that is associated with the prevention of adherence of P-fimbriated *E. coli* to uroepithelial cells, the putative mechanism in the prevention of urinary tract infections. Proanthocyanidin content is now used to market cranberry products (including juice, sweetened dried cranberries, and dietary supplements) and consumers widely recognize cranberries as healthy. Therefore, all of the subjects that were discussed at the XXIX ICP and 9th TC and the chapters of this volume of *Recent Advances in Polyphenol Research* are of direct importance to Wisconsin's cranberry industry. The role of polyphenols in this industry is an excellent example of the importance of polyphenol research in general.

The XXIX ICP and 9th TC were attended by 189 registrants from 23 countries, with 62 invited and contributed presentations and 104 posters. This seventh edition of *Recent Advances in Polyphenol Research* presents 11 chapters that represent the work of the invited speakers at the XXIX ICP and 9th TC and reflect the depth of science in this important field of natural product chemistry. The conference included sessions on the chemistry and physical chemistry of polyphenols; synthesis, genetics and metabolic engineering of polyphenols; the effects of polyphenols on the nutrition and health of humans and animals; the role of polyphenols in plants and ecosystems; applied research on polyphenols; and a special session devoted to the 9th Tannin Conference.

We owe a special thanks to Hannah Scott and Laura Richards from the Campus Events Services, UW–Madison, for their professional and excellent organization of the conference. Finally, we thank all of the participants, some who traveled a great distance to come to Madison, for making the conference a very enjoyable event and a wonderful learning experience.

Jess Dreher Reed
Victor Armando Pereira de Freitas
Stéphane Quideau

Acknowledgements

The editors wish to thank all of the members of the Groupe Polyphénols Board Committee

(2016–2018 & 2018–2020) for their guidance and assistance throughout this project.

Groupe Polyphénols Board 2016–2018 & 2018–2020

Dr. Denis Barron
Dr. Luc Bidel
Dr. Catherine Chèze
Dr. Peter Constabel
Prof. Olivier Dangles
Dr. Kevin Davies
Prof. M Teresa Escribano
Prof. Victor Armando Pereira de Freitas
Prof. Kazuhiko Fukushima
Dr. David Gang
Dr. Sylvain Guyot
Prof. Ann E. Hagerman
Prof. Heidi Halbwirth
Prof. Amy Howell
Dr. Stefan Martens
Dr. Fulvio Mattivi
Dr. Irene Mueller-Harvey
Prof. Stéphane Quideau
Prof. Jess Dreher Reed
Dr. Erika Salas
Prof. Juha-Pekka Salminen
Prof. Kathy Schwinn
Dr. David Vauzour
Prof. Kristiina Wähälä