The discovery of resistant starch represents one of the major developments in our understanding of the importance of carbohydrates for health in the past twenty years. There has been a steady increase in knowledge of its sources, uses and physiological effects, but more information is needed on the measurement and complex physiological functions of the various types. Resistant starch is now being incorporated into commercial foods as an ingredient to increase dietary fibre intake. Both commercial and natural sources of resistant starch have been linked to an array of health benefits, especially those related to gut health.

Resistant Starch: Sources, Applications and Health Benefits covers the intrinsic and extrinsic sources of resistant starch in foods, and compares different methods of measuring resistant starch, their strengths and limitations. Applications in different food categories are addressed by recognized academic researchers and industry experts. The book includes descriptions of how resistant starch performs in bakery, dairy, snack, breakfast cereals, pasta, noodles, confectionery, meat, processed food and beverage products. It also looks at the mechanism for improving intestinal health by resistant starch in comparison to prebiotic oligosaccharides and regular dietary fibres. Other chapters cover the impact of resistant starch on blood glucose response, safety and gut microbiota composition, as well as metabolism in animal models and individual human subjects, and the book reviews research conducted into the ways in which resistant starch can support the prevention of colon cancer. Resistant Starch: Sources, Applications and Health Benefits is unique in focusing on this versatile and important ingredient, which will be of great use to a wide range of food professionals, including food scientists, product developers and manufacturers.

About the editors
Yong-Cheng Shi is Associate Professor and Director, Carbohydrate Polymers - Technology and Product Innovation, Department of Grain Science and Industry, Kansas State University, USA.

Clodualdo C. Maningat is Vice President, Applications Technology and Technical Services, MGP Ingredients, Inc., USA, Department of Grain Science and Industry, Kansas State University, USA.

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Resistant Starch
Sources, Applications and Health Benefits

Edited by

Yong-Cheng Shi
Department of Grain Science and Industry, Kansas State University, USA

Clodualdo C. Maningat
MGP Ingredients, Inc., USA; Department of Grain Science and Industry, Kansas State University, USA

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To my wife Lei and my son Gary – YCS

To my wife Josie, my daughter Barbara and my sister Susan – CCM
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**Harry J. Flint**

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Since the term ‘dietary fibre’ was first coined in 1953, it has undergone several transformations with respect to its definition, composition, analytical methodology and physiological effects. Its heterogeneous composition of naturally-occurring non-starch polysaccharides, lignin and associated substances has grown to include other synthetic or novel fibres, comprising digestion-resistant dextrins and resistant starches. Because of this diverse composition, analysts are often confronted with the challenge of accurately quantifying the level of total dietary fibre of food or beverage products. Dietary fibre is now less frequently associated with bulk or regularity and is discussed much more conspicuously with its role in attenuation of glycemic/insulinemic responses, blood cholesterol lowering, satiety effects, weight management, large bowel fermentation and changes in gut microbiota composition and metabolism in regard to their impact on the general health and well-being of consumers.

Consumer demand for fibre-rich foods and beverages in the United States, Europe and Asia-Pacific is rising due primarily to the preponderance of positive epidemiological and scientific data and also an increase in consumer awareness and support from dieticians and nutritionists. Ironically, however, many Americans on average consume only about 50–60% of their recommended daily intake of 25 g of fibre.

Resistant starch (RS), in particular, has captivated leading research scientists and prominent educators, and their investigations have been featured prominently in scientific literature on fibre. Many research activities on RS highlighted its structure, composition, functionality, in vitro and in vivo studies and performance in food and beverage products. RS has five types or classes and, therefore, it provides diverse materials for research investigators. These, together with the commercial significance of RS, account for the abundance of published articles and inventions in the scientific and patent literature. Commercial sources of RS number around 30 – a substantial increase since the first RS product was introduced to the market in 1993.
The idea of writing this book was developed from the Carbohydrate Division Symposium on resistant starch and health during the 2009 IFT Annual Meeting in Anaheim, California. The symposium attracted speakers who are leading researchers and scientists from the academia and the food industry. In order to capture the important developments in RS, with emphasis on sources, applications and health benefits, the editors embarked on a project to write this book using the symposium papers plus the contribution of invited scientists and academic professionals who excel in this important area of RS.

There are 15 chapters in the book, covering various topics on RS, such as its biosynthesis, types or classes, slowly digestible starch, methodology for measurement and food applications, and also the physiological effects of RS, primarily in the area of glycemic/insulinemic control, appetite/satiety, gut microbiota metabolism and large bowel health. This book caters to a wide audience and can be a valuable resource for students, professors, research scientists, product developers and other food industry professionals, as they investigate the ever-growing area of RS and its diverse properties, numerous food and beverage applications, commercial significance and physiological effects.
Yong-Cheng Shi, Ph.D. is Professor and Director of the Carbohydrate Polymers – Technology and Product Innovation group in the Department of Grain Science and Industry at Kansas State University in Manhattan, Kansas. He has authored or co-authored more than 40 journal articles and book chapters and holds more than 15 patents. His research interests include: structure and properties of starches; physical, chemical, and enzymatic modifications of starches, biopolymers and flours; carbohydrate and health; starch digestibility, resistant starch and dietary fibre; ingredient functionality in cereal products; and developing technologies and products for food, nutrition, emulsion, encapsulation, pharmaceutical and other industrial applications.

Dr. Shi received his B.S. in Chemical Engineering from Zhejiang University (Hangzhou, China) and his M.S. and Ph.D. in Grain Science from Kansas State University (Manhattan, Kansas). He is a professional member of the American Association of Cereal Chemists International and Institute of Food Technologists. He is an associate editor for Cereal Chemistry and a member of Advisory Board for Starch and Food Digestion journals.

Clodualdo ‘Ody’ C. Maningat, Ph.D. is Vice President of Applications Technology and Technical Services at MGP Ingredients, Inc. in Atchison, Kansas and Adjunct Faculty Member in the Department of Grain Science and Industry at Kansas State University in Manhattan, Kansas. He is a member and former chair of the Advisory Board of the Food Processing Center of the University of Nebraska in Lincoln, Nebraska. He has authored or co-authored more than 25 journal articles and book chapters in grain and food science publications and holds more than 30 patents on grain-based technologies. His research and business interests include: chemistry, modification and functionality of starches and proteins; analysis and function of dietary fibres; value-addition concepts; technology of RS4-type resistant starch; physiological
benefits of grain-derived ingredients; and research alliances with scientists and product developers in the food industry, government and academia.

Dr. Maningat received his B.S. in Chemistry from Adamson University (Manila, Philippines), his M.S. in Agricultural Chemistry from the University of the Philippines at Los Banos (Laguna, Philippines) and his Ph.D. in Grain Science from Kansas State University (Manhattan, Kansas). He is a professional member of the American Association of Cereal Chemists International, Institute of Food Technologists, American Society of Baking and American Chemical Society.
List of Contributors

Geetika Ahuja  
Department of Plant Sciences  
College of Agriculture & Bioresources  
University of Saskatchewan  
Canada

Yongfeng Ai  
Department of Food Science and Human Nutrition  
Iowa State University  
USA

Vijay Arora  
Ingredient and Process Research  
Mondelez International  
USA

Diane F. Birt  
Interdepartmental Graduate Program in Genetics  
Department of Food Science and Human Nutrition  
Nutrition and Wellness Research Center  
Iowa State University  
USA

Caroline L. Bodinham  
Department of Nutritional Sciences  
Faculty of Health and Medical Sciences  
University of Surrey  
UK

Martine Champ  
INRA, UMR 1280  
Physiologie des Adaptations Nutritionnelles  
Universite de Nantes, CRNH, IMAD, CHU de Nantes, Nantes  
France

Ravindra N. Chibbar  
Department of Plant Sciences  
College of Agriculture & Bioresources  
University of Saskatchewan  
Canada

Annette Evans  
Innovation and Commercial Development  
Tate & Lyle  
USA
xxii  List of Contributors

Harry J. Flint
Microbial Ecology Group
Rowett Institute of Nutrition and Health
University of Aberdeen
Aberdeen, UK

Bruce R. Hamaker
Whistler Center for Carbohydrate Research and Department of Food Science
Purdue University
USA

Jovin Hasjim
Queensland Alliance for Agriculture and Food Innovation
Centre for Nutrition and Food Sciences
The University of Queensland
Australia

Mark D. Haub
Department of Human Nutrition
Kansas State University
USA

Lynn Haynes
Ingredient and Process Research
Mondelez International
USA

Suzanne Hendrich
Interdepartmental Graduate Program in Genetics
Department of Food Science and Human Nutrition
Nutrition and Wellness Research Center
Iowa State University
USA

Sarita Jaiswal
Department of Plant Sciences
College of Agriculture & Bioresources
University of Saskatchewan
Canada

Jay-lin Jane
Department of Food Science and Human Nutrition
Iowa State University
USA

Hongxin Jiang
Department of Food Science and Human Nutrition
Iowa State University
USA

Li Li
Interdepartmental Graduate Program in Genetics
Department of Food Science and Human Nutrition
Nutrition and Wellness Research Center
Iowa State University
USA

Clodualdo C. Maningat
MGP Ingredients Inc., USA; Department of Grain Science and Industry
Kansas State University
USA

Barry V. McCleary
Megazyme International
Bray Business Park
Ireland
List of Contributors

M. Denise Robertson
Department of Nutritional Sciences
Faculty of Health and Medical Sciences
University of Surrey
UK

Paul A. Seib
Department of Grain Science and Industry
Kansas State University
USA

Yong-Cheng Shi
Carbohydrate Polymers – Technology and Product Innovation
Department of Grain Science and Industry
Kansas State University
USA

Radhiah Shukri
Department of Grain Science and Industry
Kansas State University
USA

Thomas M.S. Wolever
Department of Nutritional Sciences
University of Toronto
Canada; Division of Endocrinology and Metabolism
St. Michael’s Hospital
Canada

Genyi Zhang
School of Food Science and Technology
Jiangnan University
China

Yinsheng Zhao
Interdepartmental Graduate Program in Genetics
Department of Food Science and Human Nutrition
Nutrition and Wellness Research Center
Iowa State University
USA

Jeanny Zimeri
Ingredient and Process Research
Mondelez International
USA
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1 Starch Biosynthesis in Relation to Resistant Starch

Geetika Ahuja, Sarita Jaiswal and Ravindra N. Chibbar

Department of Plant Sciences, College of Agriculture & Bioresources, University of Saskatchewan, Canada

1.1 INTRODUCTION

1.1.1 Starch components

Starch is present in amyloplasts as semi-crystalline intracellular water-insoluble granules, with alternating crystalline and amorphous layers. Starch is a glucan homopolymer composed of one-quarter amylose (molecular mass $10^5$–$10^6$ Da) and three-quarters amylopectin (molecular mass $10^7$–$10^9$ Da), along with traces of lipids (0.1–1.0%) and proteins (0.05–0.5%). Amylose is essentially a linear glucan polymer, composed of $\alpha$-1,4 linked glucose residues with a degree of polymerization (dp) ranging between 800 (in maize and wheat) to more than 4500 (in potato) with sparse branching (approximately one branch per 1000 residues) (Morrison & Karkalas, 1990; Alexander, 1995). Structural and functional aspects of these glucan polymers affect starch functionality and its end use.

Amylose chains are capable of forming single or double helices. On the basis of orientation of its fibres in X-ray diffraction studies, amylose can be divided into A- and B-type allomorphs (Galliard et al., 1987). In B-type allomorph, six double helices are packed in an anti-parallel hexagonal mode surrounding the central water channel (36 $H_2O$ per unit cell). In A-type, the central water channel is replaced by another double helix, making the structure more compact. In this allomorph, only eight molecules of water per unit cell are inserted between the double helices (Galliard et al., 1987).

Amylopectin is a highly branched glucan polymer, in which $\alpha$-1,4 linked glucose residues are interspersed with $\alpha$-1,6-glucosidic linkages (4–5%).