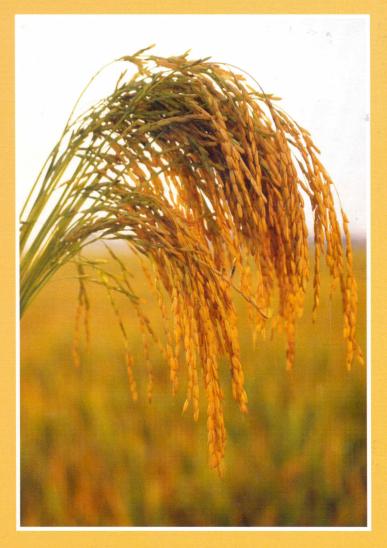
RICE

Chemistry and Technology



Elaine T. Champagne, editor

CONTENTS

1. Production and Utilization of Rice. NATHAN W. CHILDS, 1

Rice Compared with Other Cereal Grains, 1

Rice Ecosystems, 2

World Rice Production, 3

Production in Major Rice-Growing Regions, 5

Southeast Asia • South Asia • China and Northeast Asia • Latin America • North America • Africa • Europe and the Middle East • Other Regions

World Rice Trade, 12

Overview • Market Structure • Major Exporters • Major Importers

Global Rice Consumption, 18

Overview • Regional and Country Comparisons • Per-Capita Analysis

Rice in the Twenty-First Century, 20

2. The Rice Plant: Growth, Development, and Genetic Improvement. ANNA MYERS McCLUNG, 25

Growth and Development of the Rice Plant, 25

Planting, Germination, and Emergence • Vegetative Growth Stage • Reproductive Stage • Grainfill Stage • Grain Harvest

Factors Influencing Grain Quality, 31

Cultural Management • Environmental Factors

Genetic Improvement of Rice, 33

U.S. Breeding History • Genetic Variability • Population Structure and Breeding Line Development • Breeding Goals and Selection Methods

3. Rice Varieties. K. A. K. MOLDENHAUER, J. H. GIBBONS, and K. S. McKENZIE, **49**

Variety Origin and Classification, **50**Southern Region • California

Leading Varieties, 55

Southern Region • California

Varietal Quality Characteristics, **63**Southern Region • California

4. The Rice Grain and Its Gross Composition. ELAINE T. CHAMPAGNE, DELILAH F. WOOD, BIENVENIDO O. JULIANO, and DONALD B. BECHTEL, 77

Gross Structure of the Rice Grain, 77

Overall Structure • Hull • Caryopsis • Pericarp • Seed

Composition of the Rice Grain and Its Milling Fractions, 88

Proximate Analysis of Rough Rice and Its Fractions • Hull • Bran • Milled Rice • Brown Rice

Factors Affecting Composition, 96

Management and Cultural Practices • Soil • Climate • Location on Panicle • Genotypic Differences • Processing

Summary, 100

5. Starch. MELISSA FITZGERALD, 109

The Starch Granule, 109

Macrostructure of the Starch Granule • Microstructure of the Components

Functional Properties of Starch, 115

Glass Transition • Gelatinization • Swelling and Pasting • Retrogradation

The Enzymes of Starch Synthesis, 118

Adenosine 5'-Diphosphatase Glucose Pyrophosphorylase • The Starch Synthases • The Branching Enzymes • The Debranching Enzymes • The Disproportionating Enzyme

Conclusion, 133

6. Rice Proteins. FREDERICK F. SHIH, 143

Protein Distribution and Composition, 143

Protein Bodies • Protein Fractions • Identification of Rice Varieties • Protein Mutants

Processing of Protein Products, 149

Bran Proteins • Endosperm Proteins • Functional Properties • Utilization

Nutritional Properties, 153

Effect of Processing • Digestibility • Protein Quality • Hypoallergenicity

Conclusion, 157

7. Rice Lipids. J. SAMUEL GODBER and BIENVENIDO O. JULIANO, 163

Extraction of Lipids, 164

Major Lipid Categories, 164

Starch Lipids • Influence of Starch Purification • Nonstarch Lipids

Specific Classes Of Lipids, 173

Ferulate Esters: "Oryzanol Fraction" • Glycosyl Glycerides • Sphingolipids • Sterol Lipids • Tocopherols and Tocotrienols • Wax

Factors Affecting Lipid Composition, 183

Summary, 186

8. Physical and Mechanical Properties of Rice. OTTO R. KUNZE, YUBIN LAN, and FINIS T. WRATTEN, **191**

Grain Dimensions, 193

Mass Properties, 195

Density and Porosity • Coefficient of Thermal Expansion • Coefficient of Hygroscopic Expansion • Static and Dynamic Coefficients of Friction • Resistance to Airflow • Angle of Repose

Thermal Properties, 199

Specific Heat • Thermal Conductivity and Diffusivity • Film Heat Transfer Coefficient • Glass Transition Temperature

Hygroscopic Properties, 201

Equilibrium Moisture Content • Moisture Movement into the Grain • Hygroscopic Conductivity and Diffusivity

Mechanical Properties, 206

Tensile Strength • Compressive Strength • Modulus of Elasticity • Modulus of Toughness • Hardness

Moisture Adsorption Properties—Consequences, 211

Before Harvest • During Harvest • During Drying • After Drying

Weight-Volume Relationships, 218

Summary and Conclusions, 218

9. Rough-Rice Drying—Moisture Adsorption and Desorption. OTTO R. KUNZE and DAVID L. CALDERWOOD, **223**

Selected Historical Aspects, 224

Rice in the Field, 229

Optimum Harvest Moisture, 236

Fundamentals of Rice Drying, 238

Modeling Grain Moisture, 245

Gradients • Stresses

Commercial Rice Drying, 248

Handling Undried Rice • Storage of Undried Rice • Continuous-Flow Dryers • Multipass Drying • Tempering • Supplemental Drying with Aeration • Dryer Adjustments • Preheat Drying • Combination System

Bin Drying, 256

Equipment • Airflow Requirements • Depth of Rice • Fan-Operating Schedule • Air Delivery and Fan Power • Supplemental Heat • Stirring Augers • Handling of Materials

Corn and Small-Grain Dryers, 261

Other Drying Methods, 261

Fluid-Bed Drying • Infrared Drying • Dielectric Drying • Sack Drying

Drying in Countries Other than the United States, 262

Conclusions, 263

10. Rough-Rice Storage. TERRY A. HOWELL, JR., and ROBERT R. COGBURN, **269**

Storage Technology, 269

Structures • Management Practices

Maintenance of Rice Quality, 275

Aging • Protection of Rice from Degradation

Summary, 282

11. Rice Milling. NORRIS BOND, 283

Definition, 283

Relationship to Other Processes, 283

Stages of the Milling Process, 284

Cleaning • Brown Rice Production • Bran Removal • Classification—Removal of Broken Grains

Controlling the Rice Milling Process, 300

12. Impact of Drying, Storage, and Milling on Rice Quality and Functionality. TERRY J. SIEBENMORGEN and JEAN-FRANCOIS MEULLENET, 301

Pre-Drying Issues, 301

Respiration • Factors Affecting Respiration • Quality Effects Resulting from Respiration • Wet-Holding Effects on Rice Functionality

Drying, 307

Effects of Drying on Milling Quality • Effects of Drying on Sensory Quality • Effects of Drying on Other Functional Characteristics

Storage, 311

Effects of Storage Conditions on Functional Properties of Rice • Effects of Storage Conditions on Sensory Properties of Rice

Milling, 313

Kernel Size Uniformity • Milling System Effects on Kernel Quality • Degree of Milling Effects on Functionality • Milling Effects on Sensory Quality • Postmilling Physical Quality Reduction

Summary, 325

13. Parboiling of Rice. KSHIROD R. BHATTACHARYA, 329

History, 329

Origin of Parboiling • Discovery of the Nutritional Benefit of Parboiling • Modernization of the Parboiling Industry • Present Status of the Parboiling Industry in the World

The Process: Production of Parboiled Rice, **338**Processing Conditions • Production Systems

Changes During Parboiling, 359

Changes During Soaking • Changes in Organized Constituents • Changes in Other Constituents • Other Changes

The Product and Its Characteristics, 367

Physical Properties • Qualities of Parboiled Rice Relevant to Consumers

Fundamental Nature of Parboiled Rice, 375

Physicochemical Properties • State of Starch in Parboiled Rice • Effect of Rice Variety on Properties of Parboiled Rice • Tests for Parboiled Rice

Products from Parboiled Rice, 392

Canned Rice • Puffed Rice • Flaked Rice

The Future, 394

14. Enrichment and Fortification of Rice. DIANE WRIGHT HOFFPAUER, 405

History of Regulations, 405

Current Regulations, 406

Impact of Folic Acid Fortification, 408

Rice Enrichment Processes, 408

Powder Enrichment • Coated-Kernel Enrichment • Extruded Kernels • Application of Folic Acid

Testing Enrichment and Fortification Levels, 410

Global Rice Fortification, 411

Conclusion, 413

15. Rice End-Use Quality Analysis. C. J. BERGMAN, K. R. BHATTACHARYA, and K. OHTSUBO, **415**

Physical Properties, 418

Milling Quality • Kernel Dimensions • Grain Color

Functional Properties, 423

Hydration During Cooking • Loss of Solids During Cooking • Gelatinization
Temperature • Gel Consistency • Pasting Characteristics • Elongation Ratio •
Instrumental Measurement of Cooked-Rice Texture • Cooking of Rice for Sensory or
Instrumental Testing

Biochemical Properties, 441

Amylose Content • Amylopectin and Amylose Characteristics • Protein and Lipid Content • Aroma

General Techniques, 453

Near-Infrared Spectroscopy • Genetic Markers

Future Research Needs, 460

16. Value-Added Rice Products. HEIDI C. WILKINSON and ELAINE T. CHAMPAGNE, **473**

Grain Types, 473

Brown Rice • Regular Milled White Rice • Sweet or Waxy Rice • Aromatic Rice • Arborio Rice

Forms of Rice, 476

Unprocessed Forms • Processed Forms

Components and Co-Products, 480

Rice in Processed Foods, 482

Breakfast Cereals • Snacks • Side Dishes and Packaged Mixes • Entrées • Soups • Desserts • Baby Food • Beer • Pet Foods

Unusual Applications, 489

Meat and Analogs • Milk and Dairy Alternatives

Conclusion, 490

17. Preparation and Applications of Rice Flour. AN-I YEH, 495

Preparation, 497

High-Protein Rice Flour • Brown Rice Flour • Japanese Specialty Flours

Functional Properties, 502

Effect of Inherent Properties • Storage Effect • Milling Effect

Applications, 514

Noodles • Cakes • Crackers • Baked Products • Breakfast Cereal and Baby Foods • Rice Milk and Beverages • Miscellaneous Products

Summary, 534

18. Rice in Brewing. KIYOSHI YOSHIZAWA and YUTAKA OGAWA, 541

Rice in Sake Production, 541

Manufacture of Sake • Rice as a Principal Ingredient • Nature of Rice for Sake Brewing • Estimation of Quality of Rice as an Ingredient • Rice Processing • Alternatives in Rice Processing

Rice in Beer Production, 557

Raw Materials for Beer Production • Manufacture of Beer • Rice as an Adjunct

19. Rice Bran and Oil. FRANK T. ORTHOEFER and JENNIFER EASTMAN, **569**

Milling, 569

Rice Bran, 570

Chemical Composition • Composition of Rice Germ • Factors Affecting the Composition of Bran • Antinutritional Factors in Bran • Stabilization • Nutritional Properties of Rice Bran

Rice Bran Oil, 581

Oil Extraction • Rice Bran Oil Processing • Refined Rice Bran Oil • Rice Bran Oil Nutrition • Rice Bran Oil Utilization

Summary, 591

20. Nutritional Properties of Rice and Rice Bran. WALLACE YOKOYAMA, 595

Glycemic Properties, 595
Milled Rice • Rice Bran

Lipemic Properties, 597

Milled Rice • Rice Bran

Hypocholesterolemic Properties, **598**Rice Bran • Rice Bran Oil
Other Components of Rice, **605**Effects on Cholesterol • Effects on Cancer
Conclusions, **606**

21. Utilization of Rice Hull and Rice Straw as Adsorbents. WAYNE E. MARSHALL, 611

Utilization of Rice Hulls and Straw, **613**As a Char or an Activated Carbon • As Noncarbonized Material • As Rice Hull Ash Summary, **627**

Index, 631