

RS·C  
ROYAL SOCIETY OF CHEMISTRY



# *wheat gluten*

*edited by* P.R. SHEWRY *and* A.S. TATHAM

# Contents

## Genetics and Quality Correlations

The Genetics Of Wheat Gluten Proteins: An Overview <i>D. Lafiandra, S. Masci, R. D'Ovidio and B. Margiotta</i>	3
Improved Quality 1RS Wheats via Genetics and Breeding <i>R. A. Graybosch</i>	11
Characterisation of a LMW-2 Type Durum Wheat Cultivar with Poor Technological Properties <i>S. Masci, L. Rovelli, A.M. Monari, N.E. Pogna, G. Boggini and D. Lafiandra</i>	16
Effect of the <i>Glu-3</i> Allelic Variation on Bread Wheat Gluten Strength <i>M. Rodríguez-Quijano, M.T. Nieto-Taladriz, M. Gómez and J.M. Carrillo</i>	20
Relationship between Breadmaking Quality and Seed Storage Protein Composition of Japanese Commercial Hexaploid Wheats ( <i>Triticum aestivum</i> L.) <i>H. Nakamura</i>	25
Isogenic Bread Wheat Lines Differing in Number and Type of High $M_r$ Glutenin Subunits <i>B. Margiotta, L. Pflugger, M.R. Roth, F. MacRitchie and D. Lafiandra</i>	29
Quantitative Analyses of Storage Proteins of an Old Hungarian Wheat Population using the SE-HPLC Method <i>A. Juhász, F. Békés, Gy. Vida, L. Láng, L. Tamás, Z. Bedő</i>	34
Is the Role of High Molecular Weight Glutenin Subunits (HMW-GS) Decisive in Determination of Baking Quality of Wheat? <i>R. Lásztity, S. Tömösközi, R. Haraszi, T. Révay and M. Kárpáti</i>	38
Low Molecular Weight Glutenin Subunit Composition and Genetic Distances of South African Wheat Cultivars <i>H. Maartens and M.T. Labuschagne</i>	43
A New LMW-GS Nomenclature for South African Wheat Cultivars <i>H. Maartens and M.T. Labuschagne</i>	47

<i>Contents</i>	vii
Introduction of the D-Genome Related High- and Low- <i>M<sub>r</sub></i> Glutenin Subunits into Durum Wheat and their Effect on Technological Properties <i>D. Lafandra, B. Margiotta, G. Colaprico, S. Masci, M.R. Roth and F. MacRitchie</i>	51
Effects of HMW Glutenin Subunits on some Quality Parameters of Portuguese Landraces of <i>Triticum aestivum</i> ssp. <i>vulgare</i> <i>C. Brites, A.S. Bagulho, M. Rodríguez-Quijano and J.M. Carrillo</i>	55
Genetic Analysis of Dough Strength using Doubled Haploid Lines <i>O. M. Lukow</i>	61
Relationship Between Allelic Variation of <i>Glu-1</i> , <i>Glu-3</i> and <i>Gli-1</i> Prolamin Loci and Baking Quality in Doubled Haploid Wheat Populations <i>B. Killermann and G. Zimmermann</i>	66
<b>Biotechnology</b>	
Improvement of Wheat Processing Quality by Genetic Engineering <i>P.R. Shewry, H. Jones, G. Pastori, L. Rooke, S. Steele, G. He, P. Tosi, R. D'Ovidio, F. Békés, H. Darlington, J. Napier, R. Fido, A.S. Tatham, P. Barcelo and P. Lazzeri</i>	73
Expression of HMW Glutenin Subunits in Field Grown Transgenic Wheat. <i>R.J. Fido, H.F. Darlington, M.E. Cannell, H. Jones, A.S. Tatham, F. Békés and P.R. Shewry</i>	77
Prolamin Aggregation and Mixing Properties of Transgenic Wheat Lines Expressing 1Ax and 1Dx HMW Glutenin Subunit Transgenes <i>Y. Popineau, G. Deshayes, R. Fido, P.R. Shewry and A.S. Tatham</i>	80
Modification of Storage Protein Composition in Transgenic Bread Wheat <i>G.Y. He, R. D'Ovidio, O.D. Anderson, R. Fido, A.S. Tatham, H.D. Jones, P.A. Lazzeri and P.R. Shewry</i>	84
Transformation of Commercial Wheat Varieties with High Molecular Weight Glutenin Subunit Genes <i>G.M. Pastori, S.H. Steele, H.D. Jones and P.R. Shewry</i>	88
Modification of the LMW Glutenin Subunit Composition of Durum Wheat by Microprojectile-Mediated Transformation <i>P. Tosi, J.A. Napier, R. D'Ovidio, H.D. Jones and P.R. Shewry</i>	93
Genetic Modification of the Trafficking and Deposition of Seed Storage Proteins to alter Dough Functional Properties <i>C. Lamacchia, N. Di Fonzo, N. Harris, A.C. Richardson, J.A. Napier, P.A. Lazzeri, P.R. Shewry and P. Barcelo</i>	97

Production of Transgenic Bread Wheat Lines Over-Expressing a LMW Glutenin Subunit <i>R. D'Ovidio, R. Fabbri, C. Patacchini, S. Masci, D. Lafandra, E. Porceddu, A.E. Blechl and O.D. Anderson</i>	101
PCR Amplification and DNA Sequencing of High Molecular Weight Glutenin Subunits 43 and 44 from <i>Triticum tauschii</i> Accession TA2450 <i>M. Tilley, S.R. Bean, P.A. Seib, R.G. Sears and G.L. Lookhart</i>	105
Characterizations of Low Molecular Weight Glutenin Subunit Genes in a Japanese Soft Wheat Cultivar, Norin 61 <i>T.M. Ikeda, T. Nagamine, H. Fukuoka and H. Yano</i>	109
Characterization of the LMW-GS Gene Family in Durum Wheat <i>R. D'Ovidio, S. Masci, C. Mattei, P. Tosi, D. Lafandra and E. Porceddu</i>	113
Wheat-Grain Proteomics; the Full Complement of Proteins in Developing and Mature Grain <i>W.G. Rathmell, D.J. Skylas, F. Békés and C.W. Wrigley</i>	117
<b>Gluten Protein Analysis, Purification and Characterization</b>	
Understanding the Structure and Properties of Gluten: an Overview <i>R. J. Hamer and T. Van Vliet</i>	125
A Small Scale Wheat Protein Fractionation Method using Dumas and Kjeldahl Analysis <i>O.M. Lukow, J. Suchy and B. X. Fu</i>	132
Analysis of Gluten Proteins in Grain and Flour Blends by RP-HPLC <i>O.R. Larroque, F. Békés, C.W. Wrigley and W.G. Rathmell</i>	136
Reliable Estimates of Gliadin, Total and Unextractable Glutenin Polymers and Total Protein Content, from Single SE-HPLC Analysis of Total Wheat Flour Protein Extract <i>M.-H. Morel and C. Bar-L'Helgouac'h</i>	140
Use of a One-Line Fluorescence Detection to Characterize Glutenin Fraction in the Separation Techniques (SE-HPLC and RP-HPLC) <i>T. Aussenac and J.-L. Carceller</i>	144
Extractability and Size Distribution Studies on Wheat Proteins using Flow-Field Flow Fractionation <i>L. Daqiq, O.R. Larroque, F.L. Stoddard and F. Békés</i>	149
Durum Wheat Glutenin Polymers : A Study based on Extractability and SDS-PAGE <i>A. Curioni, N. D'Incecco, N.E. Pogna, G. Pasini, B. Simonato and A.D.B. Peruffo</i>	154

Reactivity of Anti-Peptide Antibodies with Prolamins from Different Cereals <i>S. Denery-Papini, M. Laurière, I. Bouchez, B. Boucherie, C. Larré and Y. Popineau</i>	158
Purification of $\gamma$ -Type HMW-GS <i>C. Patacchini, S. Masci and D. Lafiandra</i>	162
Biochemical Analysis of Alcohol Soluble Polymeric Glutenins, D-Subunits and Omega Gliadins from Wheat cv. Chinese Spring <i>T. Egorov, T. Odintsova, A. Musolyamov, A.S. Tatham, P.R. Shewry, P. Hojrup and P. Roepstorff</i>	166
Isolation and Characterization of the HMW Glutenin Subunits 17 and 18 and D Glutenin Subunits from Wheat Isogenic Line L88-31 <i>T. Odintsova, T. Egorov, A. Musolyamov, A.S. Tatham, P.R. Shewry, P. Hojrup and P. Roepstorff</i>	171
Verification of the cDNA Deduced Sequences of Glutenin Subunits by Maldi-MS <i>S. Foti, R. Saletti, S.M. Gilbert, A.S. Tatham and P.R. Shewry</i>	175
Development of a Novel Cloning Strategy to Investigate the Repetitive Domain of HMW Glutenin Subunits <i>K.A. Feeney, N.G. Halford, A.S. Tatham, P.R. Shewry and S.M. Gilbert</i>	179
Molecular Structures and Interactions of Repetitive Peptides based on HMW Subunit 1Dx5 <i>N. Wellner, S. Gilbert, K. Feeney, A.S. Tatham, P.R. Shewry and P.S. Belton</i>	183
Characterisation and Chromosomal Localisation of C-Type LMW-GS <i>L. Rovelli, S. Masci, D.D. Kasarda, W.H. Vensel and D. Lafiandra</i>	188
Characterization of a Monoclonal Antibody that Recognises a Specific Group of LMW Subunits of Glutenin <i>S. Hey, J. Napier, C. Mills, G. Brett, S. Hook, A.S. Tatham, R. Fido and P.R. Shewry</i>	192
Temperature Induced Changes in Prolamin Conformation <i>E.N.C. Mills, G.M. Brett, M.R.A Morgan, A.S. Tatham, P.R. Shewry</i>	196
Characterisation of $\omega$ -Gliadins from Different Wheat Species <i>H. Wieser, W. Seilmeier, I. Valdez and E. Mendez</i>	200
Identification of Wheat Varieties using Matrix-Assisted Laser Desorption/Ionization Time-of Flight Mass Spectrometry <i>W. Ens, K.R. Preston, M. Znamirowski, R.G. Dworschak, K.G. Standing and V.J. Mellish</i>	204

### Disulphide Bonds and Redox Reactions

<p>Quantitative Determination and Localisation of Thiol Groups in Wheat Flour <i>S. Antes and H. Wieser</i></p>	211
<p>Gluten Disulphide Reduction using DTT and TCEP <i>N. Guerrieri, E. Sironi and P. Cerletti</i></p>	215
<p>Model Studies on the Reaction Parameters Governing the Formation of Disulphide Bonds in LMW-Type Peptides by Disulphide Isomerase (DSI) <i>N. Bauer and P. Schieberle</i></p>	219
<p>Oxidation of High and Low Molecular Weight Glutenin Subunits Isolated from Wheat <i>W.S. Veraverbeke, O.R. Larroque, F. Békés and J.A. Delcour</i></p>	223
<p>Influence of the Redox Status of Gluten Protein SH Groups on Heat-Induced Changes in Gluten Properties <i>S.H. Mardikar and J.D. Schofield</i></p>	227
<p>Effects of Oxidoreductase Enzymes on Gluten Rheology <i>C.V. Skinner, A.A. Tsiami, G. Budolfson and J.D. Schofield</i></p>	231
<p>Glutathione: its Effect on Gluten and Flour Functionality <i>S.S.J. Bollecker, W. Li and J.D. Schofield</i></p>	235
<p>Redox Reactions during Dough Mixing and Dough Resting: Effect of Reduced and Oxidised Glutathione and L-Ascorbic Acid on Rheological Properties of Gluten <i>W.L. Li, A.A. Tsiami and J.D. Schofield</i></p>	239
<p>Redox Reactions in Dough: Effects on Molecular Weight of Glutenin Polymers as Determined by Flow FFF and MALLS <i>A.A. Tsiami, D. Every and J.D. Schofield</i></p>	244
<p>Bacterial Expression, <i>In Vitro</i> Polymerisation and Polymer Tests in a Model Dough System <i>C. Dowd, H. Beasley, and F. Békés</i></p>	249
<p><i>In Vitro</i> Polymerisation of Sulphite-treated Gluten Proteins in Relation with Thiol Oxidation<sup>1</sup> <i>M.-H. Morel, V. Micard and S. Guilbert</i></p>	254
<p>Modification of Chain Termination and Chain Extension Properties by altering the Density of Cysteine Residues in a Model Molecule: Effects on Dough Quality <i>L. Tamás, F. Békés, P.W. Gras, M.K. Morell and R. Appels</i></p>	258

<i>Contents</i>	xi
Effects of two Physiological Redox Systems on Wheat Proteins <i>F. Jarraud and K. Kobrehel</i>	262
Involvement of Redox Reactions in the Functional Changes that occur in Wheat Grain during Post-Harvest Storage <i>G. Mann, P. Greenwell, S.S.J. Bollecker, A.A. Tsiami and J.D. Schofield</i>	267
<b>Improvers and Enzymic Modification</b>	
Study of the Effect of Datem <i>P. Köhler</i>	273
Mechanism of the Ascorbic Acid Improver Effect on Baking <i>D. Every, L. Simmons, M. Ross, P.E. Wilson, J.D. Schofield, S.S.J. Bollecker and B. Dobraszczyk</i>	277
Degradation of Wheat and Rye Storage Proteins by Rye Proteolytic Enzymes <i>K. Brijs, I. Trogh and J.A. Delcour</i>	283
Characterisation and Partial Purification of a Gluten Hydrolyzing Proteinase from Bug ( <i>Eurygaster</i> spp.) Damaged Wheat <i>D. Sivri and H. Köksel</i>	287
Effects of Transglutaminase Enzyme on Gluten Proteins from Sound and Bug- ( <i>Eurygaster</i> spp.) Damaged Wheat Samples <i>H. Köksel, D. Sivri, P.K.W. Ng and J.F. Steffe</i>	291
Extracellular Fungal Proteinases Target Specific Cereal Proteins <i>M-P. Duviau and K. Kobrehel</i>	296
Study of the Temperature Treatment and Lysozyme Addition on Formation of Wheat Gluten Network: Influence on Mechanical Properties and Protein Solubility <i>B. Cuq, A. Redl and V. Lullien-Pellerin</i>	300
<b>Quality Testing, Non-Food Uses</b>	
A Rapid Spectrophotometric Method for Measuring Insoluble Glutenin Content of Flour and Semolina for Wheat Quality Screening <i>H.D. Sapirstein and W.J. Johnson</i>	307
Prediction of Wheat Protein and HMW-Glutenin Contents by Near Infrared (NIR) Spectroscopy <i>D.G. Bhandari, S.J. Millar and C.N.G. Scotter</i>	313
Laboratory Mill for Small-Scale Testing <i>J. Varga, D. Fodor, J. Nánási, F. Békés, M. Southan, P. Gras, C. Rath, A. Salgó and S. Tömösközi</i>	317

Scale Down Possibilities in Development of Dough Testing Methods <i>S. Tömösközi, J. Varga, P.W. Gras, C. Rath, A. Salgó, J. Nánási, D. Fodor and F. Békés</i>	321
Quality Test of Wheat Using a New Small-Scale Z-Arm Mixer <i>J. Varga, S. Tömösközi, P.W. Gras, C. Rath, J. Nánási, D. Fodor, F. Békés' and A. Salgó</i>	326
Effects of Protein Quality and Protein Content on the Characteristics of Hearth Bread <i>E.M. Færgestad, P. Baardseth, F. Bjerke, E.L. Molteberg, A.K. Uhlen, K. Tronsmo, A. Aamodt and E.M. Magnus</i>	331
Relationships of some Functional Properties of Gluten and Baking Quality <i>E.M. Magnus, K. Tronsmo, Å. Longva and E.M. Færgestad</i>	335
Thermal Properties of Gluten and Gluten Fractions of Two Soft Wheat Varieties <i>M.M. Falcão-Rodrigues and M.L. Beirão-da-Costa</i>	340
Use of Reconstitution Techniques to Study the Functionality of Gluten Proteins on Durum Wheat Pasta Quality <i>M. Sissons and C. Gianibelli</i>	347
Thermal Properties and Protein Aggregation of Native and Processed Wheat Gluten and its Gliadin and Glutenin Enriched Fractions <i>V. Micard, M.-H. Morel, J. Bonicel and S. Guilbert</i>	352
Wheat Gluten Film: Improvement of Mechanical Properties by Chemical and Physical Treatments <i>V. Micard, M.-H. Morel and S. Guilbert</i>	356
<b>Viscoelasticity, Rheology and Mixing</b>	
Do High Molecular Weight Subunits of Glutenin Form 'Polar Zippers'? <i>P.S. Belton, K. Wellner, E.N.C. Mills, A. Grant and J. Jenkins</i>	363
What Can NMR Tell You about the Molecular Origins of Gluten Viscoelasticity? <i>E. Alberti, A.S. Tatham, S.M. Gilbert and A.M. Gil</i>	368
Back to Basics: the Basic Rheology of Gluten <i>S. Uthayakumaran, M. Newberry and R. Tanner</i>	372
Rheology of Glutenin Polymers from Near-Isogenic Wheat Lines <i>A.W.J. Savage, P. Rayment, S.B. Ross-Murphy, P.R. Shewry and A.S. Tatham</i>	376
Fermentation Fundamentals: Fundamental Rheology of Yeasted Doughs <i>M. Newberry, N. Phan-Thien, R. Tanner, O. Larroque and S. Uthayakumaran</i>	380

<i>Contents</i>	xiii
<b>A Fresh Look at Water: its Effect on Dough Rheology and Function</b> <i>H.L. Beasley, S. Uthayakumaran, M. Newberry, P.W. Gras and F. Békés</i>	383
<b>Gluten Quality vs. Quantity: Rheology as the Arbiter</b> <i>K.M. Tronsmo, E.M. Færgestad, E.M. Magnus and J.D. Schofield</i>	387
<b>The Hysteretic Behaviour of Wheat-Flour Dough During Mixing</b> <i>R.S. Anderssen and P.W. Gras</i>	391
<b>Quantity or Quality? Addressing the Protein Paradox of Flour Functionality</b> <i>S. Uthayakumaran, M. Newberry, F.L. Stoddard and F. Békés</i>	396
<b>Effect of Protein Fractions on Gluten Rheology</b> <i>C.E. Stathopoulos, A.A. Tsiami and J.D. Schofield</i>	400
<b>Effects of HMW and LMW Glutenin Subunit Genotypes on Rheological Properties in Japanese Soft Wheat</b> <i>T. Nagamine, T.M. Ikeda, T. Yanagisawa and N. Ishikawa</i>	404
<b>Mixing of Wheat Flour Dough as a Function of the Physico-chemical Properties of the SDS-Gel Proteins</b> <i>A.C.A.P.A. Bekkers, W.J. Lichtendonk, A. Graveland and J.J. Plijter</i>	408
<b>Effects of Adding Gluten Fractions on Flour Functionality</b> <i>U.G. Purcell, B.J. Dobraszczyk, A.A. Tsiami and J.D. Schofield</i>	413
<b>Methods for Incorporating Added Glutenin Subunits into the Gluten Matrix for Extension and Baking Tests</b> <i>S. Uthayakumaran, F.L. Stoddard, P.W. Gras and F. Békés</i>	417
<b>Effect of Intercultivar Variation in Proportions of Protein Fractions from Wheat on their Mixing Behaviour</b> <i>J.M. Vereijken, V.L.C. Klostermann, F.H.R. Beckers, W.T.J. Spekking and A. Graveland</i>	421
<b>Evidence for Varying Interaction of Gliadin and Glutenin Proteins as an Explanation for Differences in Dough Strength of Different Wheats</b> <i>H.D. Sapirstein and B.X. Fu</i>	425
<b>Rheological and Biochemical Approaches Describing Changes in Molecular Structure of Gluten Protein During Extrusion</b> <i>A. Redl, M.H. Morel, B. Vergnes and S. Guilbert</i>	430
<b>Evaluation of Wheat Protein Extractability by Rheological Measurements</b> <i>H. Larsson</i>	435
<b>The Assessment of Dough Development During Mixing Using Near Infrared Spectroscopy</b> <i>J.M. Alava, S.J. Millar and S.E. Salmon</i>	439

Measurement of Biaxial Extensional Rheological Properties Using Bubble Inflation and the Stability of Bubble Expansion in Bread Doughs and Glutens <i>B.J. Dobraszczyk and J.D. Schofield</i>	442
The Effect of Dough Development Method on the Molecular Size Distribution of Aggregated Glutenin Proteins <i>K.H. Sutton, M.P. Morgenstern, M. Ross, L.D. Simmons and A.J. Wilson</i>	447
Wheat Gluten Proteins: How Rheological Properties Change During Frozen Storage <i>Y. Nicolas, R. Smit and W. Agterof</i>	451
Analysis by Dynamic Assay and Creep and Recovery Test of Glutens from Near-Isogenic and Transgenic Lines Differing in their High Molecular Weight Glutenin Subunit Compositions <i>Y. Popineau, J. Lefebvre, G. Deshayes, R. Fido, P.R. Shewry and A.S. Tatham</i>	454
Significance of High and Low Molecular Weight Glutenin Subunits for Dough Extensibility <i>I.M. Verbruggen, W.S. Veraverbeke and J.A. Delcour</i>	460
Water Activity in Gluten Issues: An Insight <i>L. De Bry</i>	464
<b>Gluten Protein Synthesis during Grain Development and Effects of Nutrition and Environment</b>	
Analysis of the Gluten Proteins in Developing Spring Wheat <i>R.J. Wright, O.R. Larroque, F. Békés, N. Wellner, A.S. Tatham and P.R. Shewry</i>	471
SDS-Unextractable Glutenin Polymer Formation in Wheat Kernels <i>T. Aussenac and J.-L. Carceller</i>	475
Environmental Effects on Wheat Proteins <i>E. Johansson</i>	480
Effects of Genotype, N-Fertilisation, and Temperature during Grain Filling on Baking Quality of Hearth Bread <i>A.K. Uhlen, E.M. Magnus, E.M. Færgestad, S. Sahlstrøm and K. Ringlund</i>	484
Interactions between Fertilizer, Temperature and Drought in Determining Flour Composition and Quality for Bread Wheat <i>F.M. DuPont, S.B. Altenbach, R. Chan, K. Cronin, and D. Lieu</i>	488

- Influence of Environment and Protein Composition on Durum Wheat  
Technological Quality 492  
*G. Galterio and M.G. D'Egidio*

### Non-Gluten Components

- Interactions of Starch with Glutens having different Glutenin Subunits 499  
*I.L. Batey*

- Influence of Wheat Polysaccharides on the Rheological Properties of Gluten  
and Doughs 503  
*A.C. Gama, D.M.J. Santos and J.A. Lopes da Silva*

- Effect of Water Unextractable Solids (WUS) on Gluten Formation and  
Properties. Mechanistic Considerations 507  
*R.J. Hamer, M.-W. Wang, T. van Vliet, H. Gruppen, J.P. Marseille and  
P.L. Weegels*

- The Impact of Water-Soluble Pentosans on Dough Properties. 512  
*W.J. Lichtendonk, M. Kelfkens, R. Orsel, A.C.A.P.A. Bekkers and J.J. Plijter*

- Isolation of a Novel, Surface Active,  $M_r$  50k Wheat Protein 519  
*J.E. van der Graaf, Z. Gan, J. Wykes and J.D. Schofield*

- Starch Associated Proteins and Wheat Endosperm Texture 521  
*H.F. Darlington, H.A. Bloch, L.I. Tesci and P.R. Shewry*

- Insect and Fungal Enzyme Inhibitors in Study of Variability, Evolution and  
Resistance of Wheat and other *Triticeae* Dum. Cereals 526  
*Al.V. Konarev*

- Production of Hexaploid and Tetraploid Waxy Lines 531  
*M. Urbano, B. Margiotta, G. Colaprico and D. Lafandra*

- Oat Globulins in Reversed SDS-PAGE 535  
*T. Sontag-Strohm*

- Puroindolines: Structural Relationships with Tryptophanins (Aveindolines)  
from Oat (*Avena sativa*) 538  
*M.A. Tanchak and I. Altsaar*

- Subject Index 545