Genetically Modified and Non-Genetically Modified Food Supply Chains: Co-Existence and Traceability
This book is dedicated to:
Sylvie who illuminates my life and supports me every day,
my parents and grandparents without whom nothing would have been.

Yves Bertheau
Genetically Modified and Non-Genetically Modified Food Supply Chains: Co-Existence and Traceability

Edited by Yves Bertheau
Research Director
Institut National de la Recherche Agronomique (INRA)
France

Co-Extra
CO-EXISTENCE & TRACEABILITY

WILEY-BLACKWELL
A John Wiley & Sons, Ltd., Publication
Contents

List of Contributors xiii
Foreword xxi
G. Riba. Vice-Chairman of INRA

Part 1: Introduction 1
1 Introduction to the GM and Non-GM Supply Chain Co-Existence and Traceability 3
Y. Bertheau, J. Davison
1.1 Introduction 3
1.2 GMO Development 3
1.3 Opinions and Attitudes of European Citizens and Consumers 4
1.4 The Different Regulatory Frames and Risk Perception 6
1.5 European Traceability and Co-Existence Frames 8
1.6 Other Issues 11
1.7 Conclusion 12
References 12

Part 2: Managing Gene Flow 21
2 Contributions of Pollen and Seed to Impurity in Crops – A Comparison of Maize, Oilseed Rape and Beet 23
G.R. Squire, J. Lecomte, A. Hüskens, J. Soukup, A. Messéan
2.1 Introduction 23
2.2 Maize 23
2.3 Oilseed Rape 26
2.4 Beet 29
2.5 Comparison of Species Based on Plant Traits 30
References 32

3 Co-Existence Issues of GM Sugar Beet 35
H. Darmency
3.1 Introduction 35
3.2 Sugar Beet in the World 35
3.3 Overview of Sugar Beet Biology and Agronomy 36
3.4 Pre-cultivation Co-existence Issues 39
3.5 Consequences of Co-existence for the Cropping System in a Region 42
3.6 Consequences of Co-existence for the Genetic Resources 45
3.7 Post-harvest Co-existence Issues 45
3.8 Conclusion 46
References 46
## Contents

### Part 1: Ex Ante Evaluation of Gene Flow in Oilseed Rape with Cropping System Models

4 Ex Ante Evaluation of Gene Flow in Oilseed Rape with Cropping System Models 49  
**N. Colbach**

4.1 Introduction 49  
4.2 Modelling Approach 50  
4.3 The Simulation Methodology 51  
4.4 Perspectives 58  
References 59

### Part 2: Biological Containment Strategies for Transgenic Crops

5 Biological Containment Strategies for Transgenic Crops 61  
**R.A. de Maagd, K. Boutilier**

5.1 Introduction 61  
5.2 Auxotrophy 63  
5.3 Inhibition of Flowering and Complete Sterility 63  
5.4 Cleistogamy 63  
5.5 Transgene Excision 64  
5.6 Chloroplast Transformation 65  
5.7 Male Sterility 67  
5.8 Parthenocarpy 68  
5.9 Apomixis 69  
5.10 Reduced Shattering 70  
5.11 Blocking Seed Germination 70  
5.12 Inhibiting Seed Dormancy 72  
5.13 Transgenic Mitigation 72  
5.14 Concluding Remarks 73  
References 73

### Part 3: Long-Distance Pollen Flow in Large Fragmented Landscapes

6 Long-Distance Pollen Flow in Large Fragmented Landscapes 79  

6.1 Introduction 79  
6.2 Evidence for Long-distance Cross-pollination of Maize 80  
6.3 Modelling Regional Pollen Transport 81  
6.4 Model Evaluation 83  
6.5 Simulated Regional Pollen Dispersal 84  
6.6 Conclusions and Perspectives 84  
References 87

### Part 4: Current and Future Availability of Non-Genetically Modified Soybean Seeds in the USA, Brazil and Argentina

7 Current and Future Availability of Non-Genetically Modified Soybean Seeds in the USA, Brazil and Argentina 89  
**J. Milanesi**

7.1 Introduction 89  
7.2 Global Overview of the Soybean and Soybean Seed Markets and Related Short-term Issues 90  
7.3 Soybean Plant Breeding and Availability of Non-GM Soybean Seeds 94  
7.4 The Future of Non-GM Plant Breeding 104  
7.5 Conclusion 109  
References 110

### Part 5: Co-Existence in Food and Feed Supply Chains

8 Consumers’ Opinions and Attitudes Towards Co-existence of GM and Non-GM Food Products

**M. Costa-Font, R.B. Tranter; J.M. Gil**

8.1 Introduction 115  
8.2 Study Methodology 116
## Contents

8.3 Literature Review Results 120  
8.4 Consumer Survey Results 121  
8.5 Conclusions 124  
References 124  

9 Evaluation of Collection Strategies for Landscape and Product Flow Management 127  
*F.C. Coléno, F. Angevin*  
9.1 Introduction 127  
9.2 Evaluation of Co-Existence Management Strategies for Grain Merchants 128  
9.3 Evaluation of Collection Strategies at the Landscape Level 134  
9.4 Conclusion 135  
References 138  

10 Empirical Analysis of Co-Existence in Commodity Supply Chains 141  
10.1 Introduction 141  
10.2 Framework 141  
10.3 Methodology 143  
10.4 Results 145  
10.5 Conclusion 155  
References 157  

11 Modelling and Assessing the Impacts of the Co-Existence Between GM and non-GM Supply Chains: The Starch Maize Supply Chain Example 161  
*B. Lécroart, A. Messéan, L-G. Soler*  
11.1 Introduction 161  
11.2 Material Flow and Risks of Commingling in the Starch Maize Supply Chain 162  
11.3 Model Description 163  
11.4 Sensitivity Analysis 167  
11.5 Results and Discussion 170  
11.6 Conclusion 173  
References 173  

12 Costs of Segregation and Traceability Between GM and Non-GM Supply Chains of Single Crop and Compound Food/Feed Products 177  
*K. Menrad, A. Gabriel, J. Bez, M. Gylling, A. Larsen, M. Maciejczak, M. Stolze, N. Gryson, M. Eeckhout, N. Pensel, R. Rocha dos Santos, A. Messéan*  
12.1 Objectives 177  
12.2 Introduction and Regulatory Framework 177  
12.3 Methodology 179  
12.4 Results 181  
12.5 Conclusions 189  
References 191  

13 Labelling and Co-Existence Regulation of GMOs and Non-GMOs: An Economic Perspective 193  
*M. Desquilbet, S. Poret*  
13.1 Introduction 193  
13.3 Labelling May Improve Welfare But Is Not A First-Rank Policy to Address Consumer Concerns 201  
13.4 Externality Costs of Co-Existence Without A Co-existence Regulation 204
Contents

13.5 Co-Existence Regulation 205
13.6 Conclusion 209
Appendix 210
References 211

14 Co-Existence and Traceability in Supply Chains: A Case Study on Belgian Compound Feed
N. Gryson, M. Eeckhout
14.1 Compound Feed Production 215
14.2 Traceability and Segregation Systems 218
14.3 Other Costs and Benefits along the Supply Chain 224
14.4 Changing Strategies 230
14.5 Conclusion 236
References 237

Part 4: Traceability and Controls in Food and Feed Supply Chains 243

15 GMO Sampling Strategies in Food and Feed Chains
15.1 Introduction 245
15.2 The EC Recommendation 2004/787: Methodologies, Applications and Limitations 246
15.3 Co-Extra Results for Different Scenarios of the Food and Feed Chain 246
15.4 Conclusion 267
References 269

16 Harmonised Reference Genes and PCR Assays for GMO Quantification
16.1 Introduction: Regulatory Framework on Reference Assays 273
16.2 Overview of Existing Reference Assays 274
16.3 Reliability Testing of Existing Reference Assays 274
16.4 Harmonised Definitions, Terminology and Technical Criteria for Designing New Reference Assays 277
16.5 Core Collections for Specificity, Uniformity and Stability Testing of Reference Assays for GMO Quantification 280
16.6 Conclusion 289
References 290

17 The Modular Approach in GMO Quality Control and Enforcement Support Systems
17.1 Enforcing the Legal GMO Framework by Harmonised Control Analysis 293
17.2 Validation of GMO Test Methods: A Modular Versus a Global Approach 294
17.3 Co-Extra Assessment of the Modular Approach in GMO Analysis 295
17.4 Decision Support Systems (DSS) Within a Modular Approach 303
17.5 Modular Approaches and Enforcement Implementation 304
17.6 Conclusion 304
References 305
Contents

18 Reliability and Cost of GMO Detection 307

18.1 Introduction 307
18.2 Accurate Determination of the Limit of Detection Associated with GMO Analysis 308
18.3 Improvements in the Limit of Quantification 310
18.4 Reliability of GMO Quantification 313
18.5 DNA Extraction from Highly Processed Matrixes 317
18.6 Evaluation of Alternative Chemistries in Real-time PCR 318
18.7 Evaluation of Different Machines for GMO Quantification by Real-time PCR 321
18.8 Evaluation of Automation Potential in GMO Detection 324
18.9 Conclusions and Perspectives 327
References 329

19 New Multiplexing Tools for Reliable GMO Detection 333

19.1 Introduction 333
19.2 From Duplex to Oligoplex PCR 336
19.3 Non-PCR Methods 352
19.4 High Grade Multiplex Approaches 356
19.5 Conclusions 360
References 361

20 Towards Detection of Unknown GMOs 367

20.1 Introduction 367
20.2 Classifications of GMOs Relevant to Detection 368
20.3 Detection of GMOs – A Short Review 371
20.4 Detection of Unauthorised GMOs 378
20.5 Detection of Unknown GMOs 379
20.6 Conclusion 380
References 380

21 Method Validation and Reference Materials 383
   G. Belloccchi, Y. Bertheau, M. De Giacomo, A. Holst-Jensen, R. Macarthur, M. Mazzara, R. Onori, I. Taverniers, M. van den Bulcke, S. Trapmann

21.1 The Concept of Validation 383
21.2 Single Laboratory Validation 385
21.3 Collaborative Validation of Methods 386
21.4 Innovative Statistical Approaches for Method Validation 387
21.5 The Modular Approach 388
21.6 The Use of CRMs (Certified Reference Materials) and Possible Alternatives in View of Standardisation and Accreditation 390
Contents

21.7 Addressing the Compatibility of the Control Plans throughout the Chains 393
21.8 Conclusion and Perspectives 397
References 398

Part 5: Legal Regimes, Liability and Redress Issues 403
22 Liability and Redress Options for Damage Caused by GMOs 405
B.A. Koch

22.1 Introduction 405
22.2 Prevention of Future Harm 406
22.3 Redress for Damage 406
22.4 Outlook 412
References 413

23 Legal Issues, an Overview on Co-Existence Policies: Technological Pluralism, Confidence Economy, Transnational Supply Chains 415

23.1 Introduction 415
23.2 The Juridical Nature of Co-Existence Policy 416
23.3 Keypoints of Supply Chain Structuring 419
23.4 Import Supply Chains and GMOs 424
23.5 A Liability System Adapted to a Controversial Technology 428
23.6 Conclusion 430
References 430

24 The Judge’s Role Concerning Science in Precautionary Measures: A Shift from Guide to Arbiter 433
C. Noiville

24.1 Introduction 433
24.2 The Judge: A Guide to Administrative Action 434
24.3 Judges as Arbitrators of Scientific Assessments? 447
24.4 Conclusion 454
References 454

Part 6: Data Integration and DSS 459
25 The Co-Extra Decision Support System: A Model-Based Integration of Project Results 461

25.1 Introduction 461
25.2 Approach and Methodology 462
25.3 Components of the Co-Extra DSS 464
25.4 Assessment of Analytical Methods 464
25.5 Assessment of Sampling Methods 472
25.6 Assessment of Products Using Traceability Data 477
25.7 Assessment of Processes 482
25.8 Database and Web-based Implementation 485
25.9 Conclusions 487
References 488
## Contents

### Part 7: Related Issues

26 Integration of Co-Extra Results in EU Tools for Traceability

*G. van den Eede, D. Plan*

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>26.1 Overview of EU Legislation on GMOs</td>
<td>493</td>
</tr>
<tr>
<td>26.2 Achievements in the EU Harmonisation of GMO Analysis</td>
<td>497</td>
</tr>
<tr>
<td>26.3 Challenges Ahead</td>
<td>499</td>
</tr>
<tr>
<td>26.4 Conclusion</td>
<td>518</td>
</tr>
</tbody>
</table>

26.5 References | 518 |

27 Labelling and Detection of GM Crops and Derived Products: Regulatory Frameworks and Research Issues in East Asia


<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.1 Introduction</td>
<td>521</td>
</tr>
<tr>
<td>27.2 People’s Republic of China</td>
<td>522</td>
</tr>
<tr>
<td>27.3 Korea</td>
<td>527</td>
</tr>
<tr>
<td>27.4 Taiwan</td>
<td>532</td>
</tr>
<tr>
<td>27.5 Japan</td>
<td>534</td>
</tr>
<tr>
<td>27.6 Conclusion</td>
<td>538</td>
</tr>
</tbody>
</table>

27.7 References | 539 |

28 Maintaining a Supply of Non-GM Feed – A Strategic Issue for European Regional Agriculture

*R. Layadi*

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>28.1 Introduction</td>
<td>543</td>
</tr>
<tr>
<td>28.2 The GMO-free Regions Network</td>
<td>544</td>
</tr>
<tr>
<td>28.3 The Feed Question: A Major Issue for Regional Agriculture</td>
<td>544</td>
</tr>
<tr>
<td>28.4 GMO-free Agriculture, a Vital Issue for Regions</td>
<td>548</td>
</tr>
<tr>
<td>28.5 Getting a Solid Strategic and Tactical Background: Lessons from the Cold War</td>
<td>550</td>
</tr>
</tbody>
</table>

28.7 References | 555 |

29 A Geographical Approach to the European Policy for the Co-Existence of GMO and Non-GMO Crops

*E. Glon*

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>29.1 Introduction</td>
<td>563</td>
</tr>
<tr>
<td>29.2 EU Scenarios for the Co-Existence of GM and Non-GM Crops</td>
<td>564</td>
</tr>
<tr>
<td>29.3 Dedicated Areas – A Geographical Analysis</td>
<td>571</td>
</tr>
<tr>
<td>29.4 A Few Lines for Thought with Regard to Co-Existence in Territories</td>
<td>580</td>
</tr>
<tr>
<td>29.5 Conclusion</td>
<td>585</td>
</tr>
</tbody>
</table>

29.6 References | 587 |

30 Segregating Supply Chains: a Cost–Benefit Perspective

*J.K. Hammitt, W.W. Wilson*

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>30.1 Introduction</td>
<td>591</td>
</tr>
<tr>
<td>30.2 Social Benefits of Co-Existence</td>
<td>591</td>
</tr>
<tr>
<td>30.3 Consumer Valuation of GMO-free Foods</td>
<td>593</td>
</tr>
<tr>
<td>30.4 Background on Developments in North American Wheat</td>
<td>595</td>
</tr>
<tr>
<td>30.5 Costs of Segregating Wheat to Conform to EU Traceability Standards</td>
<td>595</td>
</tr>
<tr>
<td>30.6 Contract Mechanisms to Facilitate Co-Existence</td>
<td>596</td>
</tr>
<tr>
<td>30.7 Summary and Implications</td>
<td>602</td>
</tr>
<tr>
<td>30.8 Conclusion</td>
<td>602</td>
</tr>
</tbody>
</table>

30.9 References | 603 |
Contents

31 Co-Existence and Traceability in the EU Versus IP Systems in Third Countries 605
  R. Rocha dos Santos, N. Pensel, R. Green
  31.1 Introduction 605
  31.2 Mercosur and Europe: Different But Complementary 606
  31.3 The GM Soybeans in Mercosur 606
  31.4 Food Regulation 609
  31.5 EU, Mercosur and Traceability 610
  31.6 Contracts and Private Regulations 611
  31.7 Third Party Certification Companies, the Key Players 612
  31.8 The Traders’ Role 613
  31.9 Final Considerations 614
  References 615

Part 8: Conclusion 617

32 GM and Non-GM Supply Chain Co-Existence and Traceability: Context and Perspectives 619
  Y. Bertheau
  32.1 Introduction 619
  32.2 Background 619
  32.3 Co-Existence 624
  32.4 Traceability 628
  32.5 Conclusion 629
  References 630

Index 643

Plate section fall between pages 314 and 315
List of Contributors

T. Allnutt
The Food and Environment Research Agency, York, UK

F. Angevin
Institut National de la Recherche Agronomique (INRA), Thiverval-Grignon, France

S. Anvar
Centre de Recherche en Droit des Sciences et Techniques, Université Paris I, CNRS, Paris, France

A. Audran
Arvalis – Institut du végétal, Montardon, France

M. Ayadi
Institut National de la Recherche Agronomique (INRA), Versailles, France

V. Baeten
CRA-W, Centre wallon de Recherches agronomiques, Gembloux, Belgium

C. Bahrdt
Eurofins GeneScan GmbH, Freiburg, Germany

N. Bargues
Centre de Recherche en Droit des Sciences et Techniques, Université Paris I, CNRS, Paris, France

S. Baumler
Eurofins GeneScan GmbH, Freiburg, Germany

G. Bellocchi
JRC-IHCP, European Commission Joint Research Centre, Institute for Health and Consumer Protection- Molecular Biology and Genomics, Ispra, Italy

G. Berben
CRA-W, Centre wallon de Recherches agronomiques, Gembloux, Belgium

K.G. Berdal
National Veterinary Institute, Oslo, Norway

Y. Bertheau
Institut National de la Recherche Agronomique (INRA), Versailles, France

J. Bez
PhG-IVV, Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung, Institute of Process Engineering and Packaging, Freising, Germany

A. Blejec
National Institute of Biology, Ljubljana, Slovenia

M. Bohanec
Jožef Stefan Institute, Department of Knowledge Technologies, Ljubljana, Slovenia; University of Nova Gorica, Nova Gorica, Slovenia

J. Bohlin
National Veterinary Institute, Oslo, Norway

M. Bonin
Centre de Recherche en Droit des Sciences et Techniques, Université Paris I, CNRS, Paris, France

R. Bourgier
Institut National de la Recherche Agronomique (INRA), Thiverval-Grignon, France

K. Boutilier
Bioscience Business Unit, Plant Research International, Wageningen University and Research Center, Wageningen, Netherlands

C. Bøydler Andersen
National Veterinary Institute, Oslo, Norway
List of Contributors

C. Brera
ISS, National Institute of Health, Rome, Italy

P. Brodmann
Biolytix, Witterswil, Switzerland

Y. Brunet
Institut National de la Recherche Agronomique (INRA), Villenave d’Ornon, France

M. Buh Gašparič
National Institute of Biology (NIB), Department of Biotechnology and Systems Biology, Ljubljana, Slovenia

M. Burns
Laboratory of the Government Chemist, Analytical Technology, London, UK

A.M. Burrel
Laboratory of the Government Chemist, Analytical Technology, London, UK

K. Cankar
National Institute of Biology (NIB), Department of Biotechnology and Systems Biology, Ljubljana, Slovenia

G. Canselier
Centre de Recherche en Droit des Sciences et Techniques, Université Paris I, CNRS, Paris, France

Z. Čergan (Deceased)
Agricultural Institute of Slovenia, Ljubljana, Slovenia

M. Chaouachi
Institut National de la Recherche Agronomique (INRA), Versailles, France

N. Colbach
Institut National de la Recherche Agronomique (INRA), Dijon, France

F.C. Coléno
Institut National de la Recherche Agronomique (INRA), Thiverval-Grignon, France

A. Coll
Institute of Agro-Food Technology INTEA, Universitat de Girona, Girona, Spain

J. Copeland
The Food and Environment Research Agency, York, UK

M. Costa-Font
CREDA-UPC-IRTA, Barcelona, Spain

H. Darmency
Institut National de la Recherche Agronomique (INRA), Dijon, France

J. Davison
Institut National de la Recherche Agronomique (INRA), Versailles, France (retired)

S. Dayau
Institut National de la Recherche Agronomique (INRA), Villenave d’Ornon, France

R.A. de Maagd
Bioscience Business Unit, Plant Research International, Wageningen University and Research Center, Wageningen, Netherlands

M. de Giacomo
ISS, National Institute of Health, Rome, Italy

M. de Vivo
ISS, National Institute of Health, Rome, Italy

M. Debeljak
Jožef Stefan Institute, Ljubljana, Slovenia

S. Delage
Institut National de la Recherche Agronomique (INRA), Villenave d’Ornon, France

S. Desmoulins
Centre de Recherche en Droit des Sciences et Techniques, Université Paris I, CNRS, Paris, France

M. Desquilbet
Toulouse School of Economics and Institut National de la recherche Agronomique (INRA), Toulouse, France

D. Dobnik
Dept. of Biotechnology and Systems Biology, National Institute of Biology, Ljubljana, Slovenia

S. Dupont
Institut National de la Recherche Agronomique (INRA), Villenave d’Ornon, France
List of Contributors

M. Eeckhout
Department of Food Science and Technology, Faculty of
Applied Bio-Sciences Engineering, University College
Ghent, Belgium

J. Escobar
Laboratoire d’Aéologie, Toulouse, France

T. Esteve
Centre de Recerca en Agrigenòmica (CRAG), Barcelona,
Spain; Consorci CSIC-IRTA and IBMB-CSIC,
Barcelona, Spain

J.A. Fernandez Pierna
CRA-W, Centre wallon de Recherches agronomiques,
Gembloux, Belgium

X. Foueillassar
Arvalis – Institut du végétal, Montardon, France

R. Freyer
Eurofins GeneScan GmbH, Freiburg, Germany

A. Gabriel
Straubing Center of Science, Weihenstephan-Triesdorf
University of Applied Sciences, Germany

D. Garrigou
Institut National de la Recherche Agronomique (INRA),
Villenave d’Ornon, France

G. Ghezan
INTA, Instituto Nacional de Tecnología Agropecuaria,
Argentina

J.M. Gil
CREDA-UPC-IRTA, Barcelona, Spain

E. Glon
Lille University of Science and Technology, Department
of Geography and Town and Country Planning, TVES
laboratory, Villeneuve d’Ascq, France

R. Green
Institut National de la recherche Agronomique (INRA),
Ivry-sur-Seine, France (retired)

K. Gruden
Department of Biotechnology and Systems Biology,
National Institute of Biology (NIB), Ljubljana, Slovenia

N. Gryson
Department of Food Science and Technology, Faculty of
Applied Bio-Sciences Engineering, University College
Ghent, Belgium

D. Guyon
Institut National de la Recherche Agronomique (INRA),
Villenave d’Ornon, France

M. Gylling
FOI, Institute of Food and Resource Economics,
University of Copenhagen, Denmark

S. Hamels
EAT, Eppendorf Array Technologies SA, Namur,
Belgium

J.K. Hammitt
Harvard Center for Risk Analysis, Harvard School of
Public Health, Harvard University, Boston, USA

M.-A. Hermitte
Centre de Recherche en Droit des Sciences et
Techniques, Université Paris I, CNRS, Paris, France

A. Holck
Nofima mat AS, As, Norway

A. Holst-Jensen
National Veterinary Institute, Oslo, Norway

A. Hüsken
Julius Kühn Institute, Federal Research Centre for
Cultivated Plants (JKI), Institute for Biosafety of
Genetically Modified Plants, Braunschweig, Germany

E. Janssen
CRA-W, Centre wallon de Recherches agronomiques,
Gembloux, Belgium

K. Kitta
National Food Research Institute, Ibaraki, Japan

B.A. Koch
Institut für Zivilrecht, Universität Innsbruck, Innsbruck,
Austria

E.J. Kok
RIKILT Wageningen UR, Wageningen, The
Netherlands
List of Contributors

P. Kozjak
Agricultural Institute of Slovenia, Ljubljana, Slovenia

A. Krech
Eurofins GeneScan GmbH, Freiburg, Germany.

A.B. Kristoffersen
National Veterinary Institute, Oslo, Norway

B.-J. Kuo
National Chung Hsing University, Taichung, Taiwan

B. Kuznetzov
Center Bioengineering RAS, Russia

J.L. La Paz
Centre de Recerca en Agrigenòmica CSIC-IRTA-UAB (CRAG), Barcelona, Spain

C. Lac
CNRM, Météo-France, Toulouse, France

A. Langlais
Centre de Recherche en Droit des Sciences et Techniques, Université Paris I, CNRS, Paris, France

A. Larsen
FOI, Institute of Food and Ressource Economics, University of Copenhagen, Denmark

V. Laval
Institut National de la Recherche Agronomique (INRA), Versailles, France

R. Layadi
Conseil Régional de Bretagne, Rennes, France

M. Le Bail
Institut National de la Recherche Agronomique (INRA), and AgroParisTech, Thiverval-Grignon France

J. Lecomte
Université Paris-Sud; CNRS, Orsay, and AgroParisTech, Paris, France

B. Lécroart
Institut National de la Recherche Agronomique (INRA), Thiverval-Grignon, France

C.-H. Lee
Rural Development Administration, Suwon, Korea

D. Lee
National Institute of Agricultural Botany, Cambridge, UK

S.H. Lee
National Agricultural Products Quality Management Service, Korea

S. Leimanis
EAT, Eppendorf Array Technologies SA, Namur, Belgium

F. Leprince
Arvalis – Institut du végétal, Montardon, France

M. Lövoll
National Veterinary Institute, Oslo, Norway

A. Lövseth
National Veterinary Institute, Oslo, Norway

J. Luis La Paz
Consorci CSIC-IRTA and IBMB-CSIC, Barcelona, Spain

R. Macarthur
The Food and Environment Research Agency, York, UK

M. Maciejczak
Warsaw University of Life Sciences - SGGW, Poland

A. Malcevschi
Department of Environmental Sciences, University of Parma, Parma, Italy

N. Marmiroli
Department of Environmental Sciences, University of Parma, Parma, Italy

M. Mazzara
JRC-IHCP, European Commission Joint Research Centre, Institute for Health and Consumer Protection, Ispra, Italy

V. Meglič
Agricultural Institute of Slovenia, Ljubljana, Slovenia

E. Melé
Centre de Recerca en Agrigenòmica (CRAG), Barcelona, Spain
List of Contributors

K. Menrad  
Straubing Center of Science, Weihenstephan-Triolrsdorf  
University of Applied Sciences, Germany  

A. Messéan  
Institut National de la Recherche Agronomique (INRA),  
Thiverval-Grignon, France  

J. Messegue  
Centre de Recerca en Agrigenòmica (CRAG),  
Barcelona, Spain  

M. Miraglia  
ISS, National Institute of Health, Rome, Italy  

J. Milanesi  
Toulouse School of Economics and Institut National de  
la recherche Agronomique (INRA), Toulouse, France  

D. Morisset  
Department of Biotechnology and Systems  
Biology, National Institute of Biology, Ljubljana,  
Slovenia  

A. N. Nadal  
Centre de Recerca en Agrigenòmica (CRAG),  
Barcelona, Spain; Institute of Agro-Food Technology  
INTEA, Universitat de Girona, Girona, Spain  

A. Nemeth  
Eurofins GeneScan GmbH, Freiburg, Germany  

C. Noiville  
Centre de Recherche en Droit des Sciences et  
Techniques, Université Paris I, CNRS, Paris, France  

R. Oger  
University of Parma, Italy  

R. Onori  
ISS, National Institute of Health, Rome, Italy  

E. Palmaccio  
ISS, National Institute of Health, Rome, Italy  

N. Papazova  
Scientific Institute of Public Health (IPh), Section  
Biosafety and Biotechnology, Brussels, Belgium; ILVO,  
Institute for Agricultural and Fisheries Research,  
Merelbeke, Belgium  

E. Parlouer  
Service Commun des Laboratoires, Strasbourg, France  

V. Pelaez  
Universidade Federal do Paraná, Paraná Institute of  
Technology (Tecpar), Brazil  

N. Pensel  
INTA, Instituto Nacional de Tecnología Agropecuaria,  
Argentina  

J.-P. Pinty  
Laboratoire d’Aérologie, Toulouse, France  

M. Pla  
Centre de Recerca en Agrigenòmica (CRAG), Barcelona,  
Spain; Institute of Agro-Food Technology INTEA,  
Universitat de Girona, Girona, Spain  

D. Plan  
JRC-IHCP, European Commission Joint Research  
Centre, Institute for Health and Consumer Protection,  
Ispra, Italy  

V. Planchon  
CRA-W, Centre wallon de Recherches agronomiques,  
Unit of Biometry, Data processing and Agrometeorology,  
Belgium  

S. Pore  
Institut National de la Recherche Agronomique (INRA),  
Ivy-sur-Seine, and Ecole Polytechnique, Palaiseau,  
France  

E. Prantera  
ISS, National Institute of Health, Rome, Italy  

T.W. Prins  
RIKILT Wageningen UR, Wageningen, The  
Netherlands  

J. Remacle  
EAT, Eppendorf Array Technologies SA, Namur,  
Belgium  

P. Richl  
Eurofins GeneScan GmbH, Freiburg, Germany  

R. Rocha dos Santos  
UNIBRASIL-QUIS, Paraná, Brazil  

E
List of Contributors

K. Rostohar
Agricultural Institute of Slovenia, Ljubljana, Slovenia

R.B. Rud
National Veterinary Institute, Oslo, Norway

T. Ruttink
ILVO, Institute for Agricultural and Fisheries Research, Merelbeke, Belgium

C. Skjæret
National Veterinary Institute, Oslo, Norway

L-G. Soler
Institut National de la Recherche Agronomique (INRA), Ivry sur Seine, France

J. Soukup
Department of Agroecology and Biometeorology, Faculty of Agrobiology Food and Natural Resources, Czech University of Life Sciences, Prague, Czech Republic

G.R. Squire
James Hutton Institute, Dundee, UK

M. Stolze
FiBL, Forschungsinstitut für Biologischen Landbau, Switzerland

J. Šuštar-Vozlič
Agricultural Institute of Slovenia, Ljubljana, Slovenia

M. Tachikawa
Ibaraki University, Ibaraki, Japan

C. Tapia
INTA, Instituto Nacional de Tecnología Agropecuaria, Argentina

I. Taverniers
Institute for Agricultural and Fisheries Research (ILVO), Technology and Food Sciences Unit, Merelbeke, Belgium

T. Tengs
National Veterinary Institute, Oslo, Norway

R.B. Tranter
School of Agriculture, Policy and Development, University of Reading, Reading, UK

S. Trapmann
JRC-IRMM, European Commission Joint Research Centre, Institute for Reference Materials and Measurements, Geel, Belgium

A. Trouillier
Institut National de la Recherche Agronomique (INRA), Ivry sur Seine, France

P. Tulet
CNRM, Météo-France, Toulouse, France

G. Ujhelyi
RIKILT Wageningen UR, Wageningen, The Netherlands

H. Valdivia
Laboratory of the Government Chemist, Analytical Technology, London, UK

M. Van den Bulcke
Scientific Institute of Public Health, Brussels, Belgium

G. Van den Eede
JRC-IHCP, European Commission Joint Research Centre, Institute for Health and Consumer Protection, Ispra, Italy

J.P. van Dijk
RIKILT Wageningen UR, Wageningen, The Netherlands

J.C. Varela
Centre de Recherche en Droit des Sciences et Techniques, Université Paris I, CNRS, Paris, France

J. Vojvoda
National Institute of Biology (NIB), Department of Biotechnology and Systems Biology, Ljubljana, Slovenia

B. Vrščaj
Agricultural Institute of Slovenia, Ljubljana, Slovenia
List of Contributors

W.W. Wilson
North Dakota State University, Department of Agribusiness and Applied Economics, Fargo, USA

D. Wulf
Eurofins GeneScan GmbH, Freiburg, Germany

L. Yang
Shanghai Jiao Tong University, Shanghai, China

J. Žel
National Institute of Biology (NIB), Department of Biotechnology and Systems Biology, Ljubljana, Slovenia

Dabing Zhang
Shanghai Jiao Tong University, Shanghai, China

David Zhang
Groupe d’Etude et de contrôle des Variétés et Semences, laboratoire BIOGEVES, Le Magneraud, France

Haibo Zhang
National Veterinary Institute, Oslo, Norway
Shanghai Jiao Tong University, Shanghai, China

M. Žnidaršič
Jožef Stefan Institute, Ljubljana, Slovenia
In 1983, three reports from the University of Gent, the University of Washington, and the Monsanto Company showed that the Ti plasmid of Agrobacterium tumefaciens could be used to transfer foreign DNA into the plant genome, thus producing the first genetically modified (GM) plants. This discovery had enormous implications for plant genetics and agriculture. In the last 20 years, plant biotechnology has grown into a multi-billion dollar international industry while GMOs are cultivated on about 150 millions of hectares in around 25 countries.

Europe cultivates only a small amount of GM-crops (mainly GM-maize grown in Spain), though this is likely to increase in the future. This is particularly due to the European consumers’ reluctance towards GM-derived foods. The freedom of choice of European consumers has been considered by the European Commission and the Member States through a legislative frame enabling the labelling of food and feed derived from, or consisting of, GMOs. In counterpart, the freedom of producers to grow either GMO, conventional or organic products is maintained by co-existence measures along the full supply chain, that is from seed production to the retailers’ shelves.

To develop accurate product labelling and to determine a sustainable co-existence framework, several national and European research projects have been launched. The European research programs such as QPCRGMOFood and GMOChips focused first on GMO traceability and detection methods, then on co-existence issues with SIGMEA, Transcontainer and Co-Extra.

Co-Extra was for 4.5 years (2005–2009) the largest European research project on co-existence and traceability among supply chains. Co-Extra comprised 53 partners from 18 countries with more than 200 scientists with their teams. This program embraced technical, legal and socio-economic issues, starting from seed production, with questions on the availability of non-GM varieties in the long-term, to the economic costs of traceability, with pollen flow studies and detection of unapproved GMOs as some examples of the work done. Numerous papers have already been published by Co-Extra while several more detailed deliverables are available from the website.

However, after such important research, it was thought necessary to present an overview of the work done and of the results obtained through the present book.

Several non-Co-Extra authors were also asked to provide us with a summary of the results of SIGMEA and Transcontainer, modelling results not studied in the project, traceability in non-European countries with labelling policies as well as their views on, for example, GMO-free areas. Indeed, Co-Extra results show that the operators use a practical threshold of 10% of the 0.9% legal labelling threshold. This changes the paradigm of co-existence, from a flexible co-existence scheme to a dedicated production area co-existence frame. Up to now, this co-existence scheme has not been completely finalised so that technical, legal, and societal questions remain unsolved.

It is thus my pleasure to introduce this book where numerous questions find solutions, even though several others remain.

To conclude this foreword, I would like to remind readers that all the issues covered by GM and non-GM supply chain co-existence and traceability have important applications in other food and feed chain traceability areas. For instance, the strategies for detecting unapproved and unknown GMOs may be used in clinical microbiology or biodefense while the increase in the accuracy of detection methods is useful in all other areas such as gene expression. In this way, the co-existence and traceability studies of GM and non-GM supply chains contribute to the improvement of both basic and applied research, as well as to the safety and quality of food chains.

Guy Riba
Vice-Chairman of Inra
Index

Note: The suffix ‘f’ following a page locator indicates a figure, ‘n’ indicates a footnote and ‘t’ indicates a table.

A
A. (Arthrocnemum) glaucum 276t
ABIOVE (Brazilian Association of Vegetable Oil Industries) 606
Abrange 91, 231, 232, 551, 554
absolute LOD/LOQ 310 see also limit of detection and limit of quantification
absolute LODs 343 see also limit of detection
Accent 120
acyl-CoA carboxilase 276t
Achard, Carl-Franz 35, 36, 37
acyl-acyl carrier thioesterase 276t
admixture see also adventitious GM presence
admixture function at drying 164 in the fresh potato chain 144f of GM and non-GM products 144, 170, 210, 227 of GM and non-GM sugar beets 35, 39 likelihood of 284 of non-GM products 171 pressure 172 threshold values 172 processes sensitive to admixture during supply chain 156 as a result of negligence 209 risk of 161 sources of 210 adventitious GM presence (AGMP) 53, 55, 56, 57, 58, 161, 205, 256, 260, 265 farm-saved seeds 52 in OSR 50, 51 reduction of 28 regional model to assess 482 threshold on non-GMO land 581 Africa 287, 550, 622 North Africa 93 South Africa 4, 36, 230 Agreement Memorandum on Dispute Settlement 453 see also World Trade Organization agricultural production 622 agriculture agri-food safety management system in Korea 527–530 agricultural supply chains 622–623 GMO-free 548–550, 625, 626, 627 industrialised agriculture 624 quality agriculture 549 see also quality signs agronomic literature 210 alcohol 227, 582 alcoholic dehydrogenase 1 277t allergen labelling regulations 191 Amaranthaceae family 276t Amaranthus palmeri (Palmer’s pigweed) 569 AM DetQuant model 464, 466, 467f, 470f AM DNAex model 464, 465, 465f, 466, 468f AMPE software 397 AmpliFluor 319, 320, 321 Amsterdam Treaty 439 analytical method model 463 anchor PCR 230 animal feed GM soy in 253–255 labelling of 628 soybean products used in 215 animal feed manufacturers production costs 221–222 segregation costs 220–223 audits and analyses 222 benefits of 223–224 ingredient costs 220–221 total surplus cost 222–223 ANOVA tests 259, 322 AOAC 385 AOC label 582, see also quality signs apomixis 69–70, see also biocontainment and biological containment Appellate Body 450, 451, 452 see also World Trade Organization apples 69, 441, 446 Apples case 441, 442, 446 Arabidopsis 64, 65, 68, 69, 70, 73, 368 Arabidopsis thaliana 63, 379 Argentina 4, 216, 231, 237, 543, 545, 606 availability of non-GM soybean seeds in 89, 103–104, 109 certification in 612 costs and benefits of cultivating GM or non-GM soy 224–225 crop storage 147 demand for non-GM soybeans 109 equipment sharing 147 farming in 426 Flint maize chain identity preservation 151–152, see also supply chain segregation food regulation 609, 610 GM and non-GM planted areas in 91f importing of non-GM soybean seed from USA 146 intellectual property rights for plant breeders in 94 non-GM soybean seeds in 102–104, 108–109 number of GM and non-GM varieties for general use protected per year in 104f percentage share of soybean varieties registered in 103f

plant variety protection system in 95t
production of non-GM soybeans in 94
RR soybean cultivation in 607
share of soybean harvest exported to the
EU-27 606t
soy meal exported to the EU-27 606t
soy oil exported to the EU-27 606t
soybean crushing 233
soybean production in 90, 217, 606–609
soybean seed breeding industry in
102f, 103
soybean seed purity 145
supply chains analysed 143t
traceability requirements 610, 614
arginine decarboxilase 276t
Asia 521
see also East Asia
assays see reference assays and
endogenous reference gene/sequence
Atlg53101 0 osr mapping probe 276t
atmospheric model 81 see also Meso-NH
Artriplex halimus 276t
Artriplex hortensis 276t
audits 217, 221, 222
Australia 4, 36, 229, 441, 595
Austria 9, 147, 155, 216f, 440, 595
ARGE Gentechnik-frei label 552
estimated production of compound feed
216f
land management in 549
automation potential, in GMO detection
324–327
auxotrophy 62
B
Brassica juncea (Indian mustard) 70
Bacillus thuringiensis 4
background pollen 25, 39, 40, 58 see also gene flow and pollen dispersal
barley 64
barnase 63, 68, 71
BART (bioluminescent assay for real-time) detection system 335
see also LAMP-BART detection method
beans see soybeans
beef 229, 231, 424, 434, 528, 530, 545, 548, 550, 552, 553, 596
beef 29–30, 50t
characteristics of 24t
co-existence in 30
cross-pollination between crops 29
ferals 30
cross-pollination between crops 29
fodder 276
potato potential for crossing and introgression 24t
validated detection methods 501t
volunteers 30
wild sea beet 30, 37, 41, 45, 281
see also sugar beet, sea beet and Beta
Belgian Agency for the Safety of the Food Chain (FAVV-AFSCA) 217
Belgian compound feed, case study
215–241
Belgium
book of charge 217, 218, 236, 237
compound feed industry 187, 215–241
cost of feed ingredients in 216f
facts and figures 215–217
estimated production of compound feed 216f
cost calculations in single and compound food/feed value chains 179t
costs of co-existence and segregation for compound feed production in 188
estimated production of compound feed 216f
Royal Decree 217
supply chains analysed 143t
tomato supply chain 150
benefits, to farmers for cultivating GM crops 225
bestfordevelopment 466
bestforpurpose 465, 466, 469, 472, 474
Beta adanensis 37, 276t
Beta genus 276t, 281
Beta macrocarpa 36, 37, 276t
Beta maritima 37, 276t see also sea beet
Beta patula Ait. 37, 276t
Beta vulgaris 29, 36, 37, 276t, 281 see also beet and sugar beet
Betaula pendula (Birch) 63
between-increment relative standard
deviation 251, 252–253 see also sampling
between-replicate analytical relative
(standard) deviation 251, 252, 253, 254 see also sampling
bias 322, 328 see also measurement uncertainty
processing bias 314–315
of real-time PCR quantification 315–317
studies on 314
bias tests 303
bio-fuels 623
bioconfinement techniques 625, 626
see also biological containment
BIOHAZ 446 see also European Food Safety Authority
biological containment see also
bioconfinement
definition 61
and the relative position in the plant life cycle where they act 62f
for transgenic crops 61–77
bioluminescent assay for real-time (BART) detection system 335
see also LAMP-BART detection method
Biolytix 466, 469
Bioplex 353
Biotechnological Products Case 437,
439, 440, 443, 444, 451, 453
birch 63
biscuits 594
determination of GMO contents in
botanical genus 282
species 281
taxon 281
Bovine Spongiform Encephalopathy (BSE) 6, 156, 215, 423, 445, 446, 574,
607, 608, 609, 615 see also TSE
taxon 153, 184, 611, 613
Brazilian Association of Vegetable Oil Industries (ABIOVE) 606
Brazilian Consumer Protection Code
610
case study on traceability and segregation of non-GM soy in
227
certification 612
chicken meat 152–153
commercial liberation of GMOs and labelling issue in 609
demand for non-GM soybeans 109
EMBRAPA in 101, 102, 108, 109, 110
Club of Rome  623

clusters  579–580 see also co-existence cluster and dedicated production area
doctoral, likelihood of  284
doctoral  9–10, 194, 416, 624–628
agro-ecological and co-existence issues  283
and agro-environment  584–585
in beet  30
benefits of  591–593, 602
and better environmental awareness  585
calculating costs of  190
clusters and  580 see also dedicated production area
doctoral issues of GM sugar beet  35–48
doctoral management strategies for grain merchants  128–134
conditions  625–628
contract mechanisms to facilitate  595–602
and costs  628
costs of  602
dedicated production area  571–580, 625
in East Asia  539
EC guidelines on  161
EU scenarios based on thresholds  564–566
EU scenarios resulting in spatial segregation  566–568
externality costs of co-existence without co-existence regulations  204–205
in the field  210, 255–256
of GM and non-GM food products, consumers’ opinions and attitudes towards  115–126
between GM and non-GM supply chains, modelling and assessing the impacts of  161–175
of GMO and non-GMO crops
EU scenarios for  564–570
European policy  563–589
geographical implications of  563–589
in GMO and non-GMO supply chains  630
introduction to  3–20
jurisdictional nature of freedom of choice by operators  417–419
and technological pluralism  416–417
limits and borders  568–569
in maize  26, 626–628
management of  12

models and implementation of co-existence measures  29, 50–52, 626–628
in oilseed rape  28–29
policies  143, 416–419
regulation areas  209
regulations  205–209
segregated spaces and heavy checks  568
social benefits of  591–593
spatial modelling and geographical space  570–571
strategies  150–155, 156
from farm level to export  151
identity preservation  150–151
at processing level  153–155
in sugar beets, consequences of  42
in territories  580–585, 625
traceability in supply chains  215–241
and traceability in the EU versus IP systems in third countries  605–616
co-existence policies  415–431, 625–626
national  418
Co-Extra project  3, 10, 189, 249, 267, 274, 300, 315, 326, 372, 388
achievements of  461
analytical uncertainty  398 see also bias and traceability and GMO analysis and GMO detection assessment of the modular approach in GMO analysis  295–303
analysis using RR soybean GTS-40-3-2  300
based on fuzzy logic assessment  301–302
extraction method and outcome of PCR method efficiency and matrix influence  297–299
reference materials  299–300
technology equivalence  295–297
contractual purity threshold  86
database  488
DNA extraction  324
fuzzy logic assessment  301–302
identification of benefits of introducing segregation and traceability systems  184
integration of Co-Extra results in EU tools for traceability  493–520
method validation  397
organisation of  294
research conducted within  245
results on GMO sampling strategies in the food and feed chain  246–267
sampling in the field  246, 255–257
structure  294f
study of strategies farmers used in order to ensure co-existence  151
see also decision support system (DSS)
co-liability  429
Coase theorem  205
Codex Alimentarius  7, 206, 236, 386, 397
COFFS traceability program  185, 186t
Cold War  550–554
collaborative trial results  395–396
collaborative validation of methods  386–387
collection silo model  128, 129f
collection strategies see also territories deliveries of GM and non-GM grain  132f
deliveries per day for a collection with one product  132f
farmer’s choice model, variable values of  133t
grain merchant level cost of  133–134
drying costs  133t, 134
spatial strategy  134
transport costs  133f
for landscape and product flow management, evaluation of  127–139
at the landscape level  134–135
farmer’s choice model  134
input data and work hypotheses  134–135
spatial strategy  131–132, 136
temporal strategy  136
time strategy  132–133
Commission Recommendation 2003/556/EC  9, 178, 194, 206, 208, 497
Commission Recommendation 2004/787/EC  9, 246, 248, 268, 273, 293, 497t, 498, 514
Commissioner of Health and Consumers’ Protection (DG-SANCO)  8, 615
commodity supply chains, empirical analysis of co-existence in  141–160
commodity supply contracts  426–428
Common Agricultural Policy (CAP)  421, 423, 554, 555
Common Catalogue of Varieties  289
communication campaigns  121
community litigation  449
Community Plant Variety Office  289
Community Reference Laboratory (CRL-GMFF)  497–499, 514, 515, 516 see also EURL-GMFF

Index
Cucagna, Eduardo 104

cultivars 101

Cycling Probe Technology (CPT) probe 320, 321

cytoplasmic male sterility (CMS) 67

see also biotechnology and biological containment

Czech Republic 178

estimated production of compound feed 216f

D
damage to property 407

damage to repair 428–429

Darwin, Charles, theory of natural

damage to property 407

Czech Republic 178

estimated production of compound feed 216f

Index

regional model (RM) 464

sampling plans assessment 464

starch production process 464

transportation model 464, 478–479

UGM model 477–478

unapproved GMOs assessment of the potential presence of 464

see also Co-Extra project

decisions, control of the content of 449–450

dedicated production areas 571–580, 625

see also club, clusters, coexistence measures and flexible coexistence

spaces as controllable structures 571–572

DeKalb Pfizer Genetics 97

denmark 28, 45, 121, 122, 123, 124,

147, 181, 182, 183, 187, 188, 216f

CUC relatives of OSR 66

co-existence costs for sugar beet supply chain in 183f

compound feed case studies 187

cost calculations in single and compound food/feed value chains 179f

cost of co-existence and segregation for compound feed production 188t

cost of co-existence and segregation of wheat 181, 595–596

cost of co-existence and traceability of rapeseed oil 182t

cost structure for producing non-GM wheat products at industry level 184t

estimated production of compound feed 216f

risk of admixture on farms 147

sugar beet supply chain 145

supply chains analysed 143t

detection method see DNA, digital array, digital PCR, PCR, GMO analysis and GMO detection development risks 430

DEXi models 462–463, 464, 473, 486, 487 see decision support system

DEXi software 463 see decision support system
differentiation systems 180, 185, 186t
digital array heatmap 313f
digital PCR 391

combined with high-throughput nanofluidic PCR 311–313

dilution effect 172


Directive 2001/18/EC 143, 178, 493,

495, 496t

Directive 2002/49/EC 40

discrete choice analysis 117

extreme value type 1 distribution (EV1) 117

Dispute Settlement Body (DSB) of the WTO 434, 436, 437, 440,

442 see also World Trade Organization

disputes 9, 367

between GMO exporters and importers 614

settlement of 450

DMF-GEN 10

DNA 142–143, 166, 279, 333

chloroplast DNA 65
detection 361 see also GMO analysis and GMO detection

ligation for detection of specific DNA sequences 357–358

plastid DNA 65

quantification methods 297f, 298t

transmission of chloroplast DNA through hybridisation with wild relatives of OSR 66

DNA extraction 313 see also CTAB method

automation of 324–326, 328

from highly processed matrices 317–318

manual and automatic 325–326

modules and DNA extracts, modular validation of 390f

from oils 318

from soybean lecithin 318

DNA fingerprinting techniques 378

dryer model 130f, 131f, 484–485, 487

assessment of ‘Case 1’ by 485f

basic attributes for the 484t

hierarchical structure of 484f

plus-minus-1 analysis 485f

test case for the 485t

dryers 129

DSS sampling model 473 see also decision support system

DualChip GMO assay 387

microarray kit 346, 347, 348f, 350, 351, 358

V2.0 348–350

report 351f–352

duplex PCR 336–337

duplex QRT-PCR 339

Dupont de Nemours 421

dna 142–143, 166, 279, 333

detection 361 see also GMO analysis and GMO detection

ligation for detection of specific DNA sequences 357–358

plastid DNA 65

quantification methods 297f, 298t

transmission of chloroplast DNA through hybridisation with wild relatives of OSR 66

DNA extraction 313 see also CTAB method

automation of 324–326, 328

from highly processed matrices 317–318

manual and automatic 325–326

modules and DNA extracts, modular validation of 390f

from oils 318

from soybean lecithin 318

DNA fingerprinting techniques 378

dryer model 130f, 131f, 484–485, 487

assessment of ‘Case 1’ by 485f

basic attributes for the 484t

hierarchical structure of 484f

plus-minus-1 analysis 485f

test case for the 485t

dryers 129

DSS sampling model 473 see also decision support system

DualChip GMO assay 387

microarray kit 346, 347, 348f, 350, 351, 358

V2.0 348–350

report 351f–352

duplex PCR 336–337

duplex QRT-PCR 339

Dupont de Nemours 421

E

col, dried killed bacterial biomass 512t

East Asia, labelling and detection of GM crops and derived products in 521–541

EAT (Eppendorf Array Technology) DualChip 470f, 471f

fitforpurpose assessment 466

bestforpurpose assessment 465, 466, 469, 472, 474

characteristics of 462

components of 464

data-based (or data-driven) 462
database 464

and web-based implementation 485–487

dryer model 484–485

dryer model 483, 484–485

regional model (RM) 482–483

starch model 483

assessment of products 487

using traceability data 477–481

assessment of sampling methods 472–477

bestfordevelopment assessment 466

bestforpurpose assessment 465, 466, 469, 472, 474

characteristics of 462

components of 464

data-based (or data-driven) 462
database 464

and web-based implementation 485–487

dryer model 484–485

dryer model 483, 484–485

regional model (RM) 482–483

starch model 483

assessment of products 487

using traceability data 477–481

assessment of sampling methods 472–477

bestfordevelopment assessment 466

bestforpurpose assessment 465, 466, 469, 472, 474

characteristics of 462

components of 464

data-based (or data-driven) 462
database 464

and web-based implementation 485–487
European Union Reference Laboratory for Genetically Modified Food and Feed (EURL-GMFF) 290, 386

see also EURL-GMFF and CRL-GMFF

expertise 619–622

counter-expertise 621

rejection of 621

export elevators 226–227

benefits of 226–227

costs 226

F

FAO (Food and Agriculture Organization of the United Nations) 385

Treaty on phyto-genetic resources 420n

farm production 623

farm-saved seed production 421–422

farmer penalties 601

farmers 622

choice of GM or non-GM crops 624

farmer’s choice model 135

time strategy 135

feed, European directive on botanical impurities in 5

feed industry, labelling rules 237

feeding the world 623–624

feedstuffs, market for 215

FEFAC see European Feed Manufacturers Federation

ferals, oilseed rape ferals 28

Feria de Norte Semillas 104

field experiments, and data collection 474

FitForPurpose 474

FitForScreening 463
decision rules 463

fitness-for-purpose 383, 466

flexible coexistence 26, 29, 625 see also coexistence, clusters and dedicated production area

flour 162, 184t, 255, 268, 410, 425, 524t

analysis of 255t

cost and performance of control plans 254t

Danish production study 183

maize 162, 296f, 374

soybean 233, 247, 248, 249, 253

wheat 179, 180, 182

feeding the world 623–624

feed industry, labelling rules 237

feeding the world 623

food industry, new technologies in 115

food market, changes in safety and quality requirements 607–609

food preference studies 594

food regulation 142, 609–610

food safety 142

FP6 Co-Extra project 10, 328

France 35, 190, 564, 592n, 593, 626, 627

AOC label 582, 586

approval of a GMO release for experimental targets 435

average surface area of farms in 62 beet crops in 29

Charte de l’Environnement 433

charters for regional national parks 585

Clermont-Ferrand Court 449

cross-pollination of maize study 441

estimation of maize yield 80–81

economic, ethical and social committee (CEES) 620

effect of BSE crisis 607

estimated production of compound feed 216f

French Conseil d’État 441

gene flow in beet studies 43

governmental policy 206

GATT 550 see also World Trade Organization

Gemma proficiency test scheme 394

gene flow 31, 32, 79–88, 194, 205, 255, 626

in beets 35, 42–43

between GM and non-GM fields 206

in maize 24t, 26, 80–83

in oilseed rape 49–60

prediction of 43

see also cross-pollination, pollen dispersion and pollination

gene stacking 26, 332, 335, 369, 371, 624

General Food Law see Regulation (EC) No 178/2002/EC

GENESYS model 55, 56

GENESYS-Beet model 43

oilseed rape volunteers 50, 51f

gene flow 31, 32, 79–88, 194, 205, 255, 626

in beets 35, 42–43

between GM and non-GM fields 206

in maize 24t, 26, 80–83

in oilseed rape 49–60

prediction of 43

see also cross-pollination, pollen dispersion and pollination

gene stacking 26, 332, 335, 369, 371, 624

General Food Law see Regulation (EC) No 178/2002/EC

GENESYS model 55, 56

GENESYS-Beet model 43

oilseed rape volunteers 50, 51f

gene flow 31, 32, 79–88, 194, 205, 255, 626

in beets 35, 42–43

between GM and non-GM fields 206

in maize 24t, 26, 80–83

in oilseed rape 49–60

prediction of 43

see also cross-pollination, pollen dispersion and pollination

gene stacking 26, 332, 335, 369, 371, 624

General Food Law see Regulation (EC) No 178/2002/EC

GENESYS model 55, 56

GENESYS-Beet model 43

oilseed rape volunteers 50, 51f

gene flow 31, 32, 79–88, 194, 205, 255, 626

in beets 35, 42–43

between GM and non-GM fields 206

in maize 24t, 26, 80–83

in oilseed rape 49–60

prediction of 43

see also cross-pollination, pollen dispersion and pollination

gene stacking 26, 332, 335, 369, 371, 624
geographical spaces 569, 586
discontinuities that cannot be controlled by people 569–570
made up of territories that are all social constructions 572–574
spatial modelling and 570–571
see also dedicated production area and territories

Germany 10, 35, 182, 184, 189, 571, 592
co-existence costs for sugar beet supply chain in 183f
cost calculations in single and compound food/feed value chains 179

GMO crops
GM content, estimation as percentage of GM animals 369

GIS
Germplasm Resources Information germplasm 95–111, 281–287

GM detection methods, employing ligation detection 359f
GM farming, general public’s fear of potential risks of 405
GM food products, consumers’ opinions and attitudes towards non-GM and 115–126
GM food valuation studies proportions of different types of consumers 200t
WTP for non-GM products 198–199t
GM foods, safety assessment and labelling policy in Japan 534
GM microorganisms (GMMOs) 369, 548
GM plants 543
endogenous reference gene systems for detection of 524–525
increase in growth of 177
GM products, segregation strategies of non-GM and 154
GM quantifications, mean and variance normalised values for 323
GM soy, price evolutions of 234f
GM supply chains, introduction to non-GM and GM supply chain co-existence and traceability 3–20
GM target taxon 281–282 see also GM plants, reference assays and endogenous reference assays borders of 284
definition in relation to botanical taxa 282f

GMO analysis
accurate determination of the limit of detection 308–309
analytical result interpretation 515–516
analytical template 266f
Co-Extra assessment of the modular approach in 295–303 see also modular approach
costs for 222
‘Detecting GMOs’ interactive DVD 517
EU harmonisation of 497–499
EU labelling policies 517
extraction method 297
GM analysis, collaborative screening
GM adventitious presence quantification 127, 166–167, 168
distribution in the non-GM harvest 169f
in non-GM field harvests 167, 170t
GM animals 369
GM content, estimation as percentage of DNA bearing the transgene 166
GM crops
benefits of 190
cultivation of 4
post-market environmental monitoring 3, 4, 7, 8, 11, 630

see also GM content, GM plants and GMO detection
GMO crops, geographical approach to the European policy for the co-existence of non-GMO and 563–589

GMO analysis
analysis of a complex sample with mixed ingredients and processed material 376–377f
development and harmonisation of 518
differential quantitative PCR 379, 629
see also unauthorised GMOs
evaluation of automation potential in 324–327
justification of the need for more efficient and cost effective strategies for 333–334
matrix approach 372, 373, 629 see also unauthorised GMOs
new multiplexing tools for reliable 333–365
review of 371–378
single low processed ingredient 374, 375f
unit see haploid genome equivalent
see also GMO analysis, collaborative trial, collaborative validation of methods, single lab validation and screening

GMO detection database 526
GMO-free
agriculture 548–550
dedicated production areas 625
foods, consumer valuation of 593–595
labels 237
land management 549
thresholds 626, 627

GMO-free European Regions Network 232, 544, 545
business meeting 551
conference 551
goals of 544
roll-back policy 551–552
working groups 544

GMO labelling threshold 8–10, 190

GMO laboratory sample output
assessing validity of procedures from test portions from laboratory samples 266–267
impacts of measurement uncertainty on ‘real world’ actions or decision 266–267

GMO quantification
reliability of 313–317 see also GMO analysis and GMO detection

GMO sampling strategies in fields 246, 255–259, 626, 627
in food and feed chains 245–272
conclusions and future perspectives 265–266
general aspects and software tools for sample size determination 248–249
during production and distribution 248–255
sampling uncertainty 267, 268
see also sampling
GMO test methods, validation of 294–295, 296f see also validation
GMO testing 304, 514 see also GMO analysis and GMO detection
GMOChips European research project 346, 372
GMOs
assessment of health and environmental risks related to 619
attitudes of consumers in opinion polls towards 4–6, 194–195, 621
banning of 200
classifications relevant to detection 368–371
coeXisence see coexistence, dedicated production area, flexible coexistence and territories
detection unit see haploid genome equivalent
detection database 526
detection of unknown GMOs 367–382 see also unauthorised GMOs
determination of attitudes towards 4–6, 195–197, 621
development of 3–4, 367
and standardisation of event-specific detection methods for 525–526
expertise of 619–622
and counter-expertise 621
rejection of 621
externality costs of co-existence without co-existence regulations 204–205
feed and indifference to 424
fully characterised 370
gene-stacked 371
and genetic resources 625
and harm to the environment 7, 8, 10, 11,407, 619, 623, 630
harmonised control analysis 293–294
knowledge based classification of 369–371 see also unauthorised GMOs
knowledge class 1 370
knowledge class 2 370–371
knowledge class 3 371
knowledge class 4 371
known GMOs 367
labelling and co-existence regulation of non-GMOs and 193–214 see also labelling and threshold
legal classification of 368–369
liability and redress options for damage caused by GMOs 405–413
low level presence (LLP) of unapproved GMOs 236, 369, 422, 538, 549, 629
management of co-existence and traceability of 12 see also coexistence and traceability
market authorisations of 619
new production methods 629
novel characteristics of 367–368
opposition to 202, 209, 415, 619
personal injury and damage to property 406–409
prevention of future harm 406
and pure economic loss 407–408
reliability and cost of detection of 307–332
risk perception 6–7, 619–621
sample analysis, technology equivalence 295–297
special liability regimes 409
spread by pollen 584 see also gene flow and pollen dispersal
transformed with new combinations of genetic elements 371
transformed with the same genetic construct(s) as GMOs in knowledge class 1 370–371
Good Manufacturing Practices (GMP) 223, 224, 369, 370f, 413
good practices of GM and non-GM production 413
government of techniques 416, 417
Grain and Feed Trade Association (GAFTA) 427, 428
grain merchant
collection strategies 131–134
cost of different management strategies 133–134
evaluation of co-existence management strategies for 128–134
evaluation of collection strategies 133t, 134
farmer’s choice model 133t, 134
input data and work hypotheses 131t, 134–135
at the landscape level 134–135
run of the simulation model 129–131
segregation strategies 131t, 135–136 see also coexistence
allocation of GM and non-GM varieties 137f
spatial strategy 136f
simulation model 128–131
spatial strategy 130, 131–132
time strategy 130, 132–133
transport 128–129
grains 605
see also barley; corn; maize; wheat
granular-sampling relative standard deviation 253 see also sampling
Great Britain see United Kingdom
Growth Hormone case 437, 439, 440, 442, 446
GURT see bioconfinement, biological containment, Gene Use
Restriction Technology, Terminator, T-GURT and V-GURT
H
HACCP 127, 223, 224, 425, 427, 527, 528, 532, 533
Haeckel, Ernst 569
Hamilton Microlab Star Liquid Handling station 326
haploid genome equivalent (HGE) 8, 273, 303, 314, 333, 347, 391, 516, 626, 627
hard identity preservation programme 218 see also identity preservation
hard red spring wheat 597
harvest discarding 54
HEAR segregation system 185, 186f
Helms, Ted 100
hens
broiler hens 222, 228
layer hen feed 234f
herbicide resistance, in sugar beet 44
herbicides 231
sensitivity to 61
see also glyphosate
Herfindahl–Hirschman Index (HHI) 96, 97, 101, 103
hexa(6)-plex PCR-CGE-LIF 344t
hexa(6)-plex PCR-CGE-SC 344t
hexaplex PCR 343
HGE see haploid genome equivalent
Hi-Pro-soybean meal 215
high grade multiplex strategies 357–361
high mobility group protein 276t, 277t
Holland see the Netherlands
hormone case see growth hormone case
horseweed 569
human resources 574, 576t
humans, damage to 406
Hungary 554
estimated production of compound feed 216f
hygiene practices 224
I
identity preservation 150–151, 156, 205, 602, 614
of IP corn rose 608
programme 152
see also coexistence and segregation
identity preserved production and marketing programmes (IPPM) 150
Index

GMO-free Ireland Network 552–553

collaborative trial, GMO analysis, GMO detection and validation 434–447

depth control of feed 532

detection of GMOs in 531–532

differences between GAP and an environment-friendly certification system 528, 530

differences in the soybean and maize supply chains in response to GMO labelling 536–538

demand for non-GM soybeans 92
development of detection methods 534–535

development of plasmidic reference materials as calibrants 535–536

impact of GM labelling in 538

labelling system in 535t

mass-based certified reference material production 536

safety assessment and labelling policy for GM foods in 534

soybean supply chain 537

standard detection methods 534–536

Joint Research Centre (JRC) 516, 614, 629

JRC-IHCP (Institute for Health and Consumer Protection) 8, 290

see also EURL-GMFF and CRL-GMFF

JRC-IRMM (Institute for Reference Materials and Measurements) 299, 304, 629

see also CRM

judgement proof 208

judges 433

as arbiters of scientific assessments 447–454
deep judicial control 451–454
guide to administrative action 434–447

restrained control 447

role concerning science in precautionary measures 433–457

thorou control 447

venting into scientific fields 451–452

jurisprudence 433, 437, 452

K

k-nearest neighbour (k-NN) algorithm 259

KELDA project 246 see also GMO sampling strategies and sampling

KeSTE software 249 see also GMO sampling strategies and sampling

KingFisher Flex 325

known GMOs 367 see also unauthorised GMOs

Korea 521, 522, 527–532

agri-food safety management system 527–530

control of agricultural raw materials 532

control of feed 532
detection of GMOs in 531–532

differences between GAP and an environment-friendly certification system 528, 530

Korea Food and Drug Administration (KFDA) 531

living modified organisms 531

management system of agricultural and fishery LMOs in 527f

Ministry for Food, Agriculture, Forestry and Fisheries (MIFAFF) 531

National Agricultural Products Quality Management Service (NAQS) 531

regulatory framework of GMOs in 531

statutory compulsory certification system 528

statutory optional certification and mark system 528, 529

l

labelling 6, 127, 150, 178, 190, 201–204, 422, 624 see also threshold benefits of 185

and consumer concerns 201–202

EU legislation on 495

exemption from labelling requirements 495

of feed products 154

GMO-free labels 237, 625–627

government of Japan 536–538

implementing traceability and labelling policy 202–204

mandatory labelling of GM goods 203

regulations 249, 524

retailers, consumers and 228–229

traceability strategies 230–236

thresholds 8–10, 626, 627, 629

voluntary labelling of non-GM goods 203


labels 582 see also Quality signs

ARGE Gentechnik-frei label 552

see also GMO-free

GMO-free labels 237, 625–627

technology label 293

Bertheau—Genetically Modified and Non-Genetically Modified Food Supply Chains: Co-Existence and Traceability

8/15/2012 2:21:35 PM
Index

labels of origin 424, 572 see also Quality signs
lamb 552
LAMP-BART detection method 471, 472
Lancaster consumer theory 116
land management 549
Register 418
structure 568
use 571, 581, 582
see also geographical spaces and territories,
landscape and product flow management,
evaluation of collection strategies 127–139
patterns, interaction between cropping systems and 59
long-distance pollen flow in large fragmented landscapes 79–88
see also gene flow and pollen dispersal
laser induced fluorescence (LIF) 340
leaf beet 276 see also beet, Beta and sugar-beet
lecithin 318
legal appraisal 452–454
legal intervention 206–207
legal issues, co-existence policies 415–431
LFD see lateral flow device
liability 9, 10, 194, 205, 207, 237, 407, 408, 416, 417, 428
for adventitious GMO presence above labelling threshold 210
environmental liability 411
for fault versus no-fault liability 429 individuals who are liable 429–430
Member States’ liability 429
product liability 409–411
and redress options for damage caused by GMOs 405–413
of small operators 430
strict liability rules 409
see also compensation, insurance and redress
ligase chain reaction (LCR) 357–358 see also SNplex
ligation 361–362
and PCR-based strategies 356–361
amplification reaction (LAR) 358
-dependent probe amplification (LPA) 358, 359t
-detection reaction (LDR) 358
-limit of detection (LOD) 308–309, 310, 343, 384
-limit of quantification (LOQ) 310–313
definition of 310
-linearity 384
-link target taxon species 279 see also reference assays and endogenous reference gene/system taxon ingredient 279
Listeria bacteria 450
-litigation 208
community litigation 449
control of the content of decisions 449–450
national and European 448–449
precautionary principle 448
LLP see low level presence and feedstuff
LMOs (living GMOs) 527f, 531–532, 534, 548 see also Cartagena protocol
Lo-Pro soybean meal 215
locked nucleic acid (LNA) probe 320, 321, 328
LOD see limit of detection (LOD)
loop-mediated isothermal amplification (LAMP) strategy 335
LOQ see limit of quantification (LOQ)
losses, linked to GMOs 408
low level presence (LLP) of unapproved GMOs 236, 369, 422, 538, 549, 629
Luminex X-map technology 378
Lux technology 319
Luxembourg 410
M
Maastricht Treaty 293
maize 23–26, 162, 165, 215, 247, 276f
10 kDa zein 277f
1507 (TC 1507) maize 500
1507 x 59122 maize 504t
1507 x NK603 maize 501t
3272 maize 508
59122 maize 501t
59122 x 1507 x NK603 maize 507t
59122 x NK603 maize 508t
analysis of single ingredient sample of 375–376f
Bt maize 4, 127, 178, 181, 500t, 585
Bt10 maize 500t
Bt11 field maize 506t
Bt11 maize 509t
Bt11 sweet maize 500t
Bt11 x GA21 maize 510t
CBH351 (Starlink) maize 368
characteristics of 246
co-existence in 26
co-existence model 626–627
cost calculations in single and compound food/feed value chains 179
-cross-pollination 25
-long-distance 80–81
-and volunteers 146
-crushing 149
DNA quantification methods
maize feed 298t
maize grain 298t
maize tortilla 298t
effect of volunteers on GM content in non-transgenic maize yields 265–266
estimation of the contribution of GM volunteers to the GMO percentage in the yield of a conventional field 265
evaluation of the proportion of volunteers that reached the flowering stage 264–265
field sown with conventional maize showing GM volunteer plants 263f
Flint maize chain identity preservation 151–152
flour 162, 296f, 374
forage maize 162
GA21 maize 500t, 507t
germplasm 287
GMO detection in 374, 375f
GMO maize cultivation 625
grain maize 162, 181
growth of GM maize 178
landrace 26, 625
long-distance dissemination 26, 79–87, 626
LY038 Maize 510t
maize area fraction and accumulated deposition of viable pollen grains 84, 87
male-sterile cytoplasm 67
map of maize fields over the Landes region in Aquitaine region 82–83
MAPOD model 134, 163, 167, 626
Mexico 625
MIR 604 maize 506t
modelling of pollen flow 626–627
MON 810 maize 512t
MON 863 x MON 810 x NK603 maize 503t
MON 863 x MON810 maize 502t
MON 863 x NK603 maize 502t
MON 89034 maize 510t
MON 89034 x 88017 maize 513t
MON 89034 x NK603 maize 513t
Mon863 maize 500t
MON88017 maize 509t
MON88017 x MON810 maize 513t
...
see also biocoinfined and biological containment
mango 69
MAPOD model 134, 163, 167, 626 see also maize and coexistence
Marggraf, Andreas Sigismund 36
market-based initiatives 577–578
marketing 603
Maroulles cheese 582
Martin, Steve St 100, 106
material resources 574, 576
matrix approach 336, 372–374, 379 see also quantitative differential PCR
and unauthorised GMOs
measurement uncertainty 255, 265, 266, 267, 307, 387, 391, 393–397, 398, 515–516, 627
effect on assurance and enforcement of labelling 396–397
estimation using collaborative trial results 395–396
estimation using proficiency test results 394–395
see also analytical uncertainty, bias and sampling
meat 152, 210, 215, 222, 223, 237, 422, 423, 424, 549
BSE animal-infected 446 see also TSE
consumption 4, 607
demand for 216
GM-free 552, 553, 554, 595
hygiene package and GMO Regulation 178/2002 608
organic 223
prices 231
segregation during BSE crisis 156
see also beef; chicken meat; pork; veal
Mediterranean corn borer (Sesamia nonagrioides) 4
Mercour countries
co-existence and traceability differences in EU and 606
food regulation 609–610
GM soybeans in 608–609
regulatory framework 615
traceability in EU and 610–611
see also Argentina; Brazil; Paraguay; Third countries; Uruguay
Meso-NH model 79, 81 see also cross-pollination, gene flow and pollen dispersal
method validation, and reference materials 383–401
Mexico
contamination of Mexican wild corn varieties 420
GMO maize cultivation 625
See also maize landraces
microarray technology 387
Middle East 37, 93, 550
Milanesi, Leonardo 108
milk
powdered milk 550
rBST (recombinant Bovine SomatoTropin) milk 203
soybean milk 298
Ministry for Food, Agriculture, Forestry and Fisheries (MIFAFF) 529
Minor Groove Binding probe 320
mixed Nash equilibrium 599, 600, 601
MNL see conditional multinomial ogit model
modelling 162 see also atmospheric model, coexistence, gene flow,
GENESYS, MAPOD, meso-NH, pollen and software
modular approach 304, 397 see also GMO analysis and GMO detection
module transfer parameters 302–303
molecular beacons (MB) 320, 321
Monsanto 95
Monsoy 101
most probable number (MPN) 310–311, 328, 334, 339, 388, 399
MPN see most probable number
Muller, Pierre 621
multiple displacement amplification DNA (mdaDNA) 300, 392
(MDA) strategy 335
multiple oligoplex reactions in a single CGE-SC run 344–346
multiplex assays 387
GMO detection methods 334, 371, 374–378
LPA (MLPA) 358
methods 372
PCR 336, 337
universal PCR and array based detection 347f
mycotoxins 247, 268 see also sampling
N
Nanae 36 see also beet, Beta and sugar-beet
NanoDrop 298
NASBA (nucleic acids based amplification) implemented microarray analysis (NADMA) 335, 353–356, 378
applicability and cost 354–355
future use of 356–357
performance 355
principle 353–354, 354f
properties of 355f
Nash equilibrium, mixed 599, 600, 601
National Institute of Metrology, Normalisation and Quality Control (INMETRO) 612
Index

NucleoMap 96 Plant Kit 324–325
Nucleospin 466–471
evaluation for DNA extraction from feed 468f
from lecithin 468f
from maize grain 468f
from soya lecithin 469f
from tofu 468f
O
oils 215
oil(s) 228
DNA extraction from 318
oilseed rape (OSR) 26–29, 143f, 274, 276f, 375f, 376f, 504t, 505–506t
AGPM rates 55, 56t
background pollen 58
BnaDFFS collection 288
Brassica rapa 28, 29, 31, 66, 73, 288
characteristics of 24f
cleistogamy 64 see also biocenfiment and biological containment
coeistence of GMO and non-GM 28–29
over time 29
in space 29
collections of 287–288
cost calculations in single and compound food/feed value chains 179t
cost for non-GM production in Germany of 185f
costs of co-existence and segregation of 181
cropping systems 54–56
cross-pollination between crops 26–27
and volunteers 146–147
shing 149
decline of the seedbank from the last known crop 27f
effect of changes in farming practices on harvest impurity 56
eU production of 216
evaluation of gene flow in oilseed rape with cropping system models 49–60
ferals 28
gene flow model 50
GENESYS model 50
S-glucosyl transferase 276f
GM oilseed rape 57
GT73 Rapeseed 506f
imports 149
landscape 56–58
background pollen 58
flexible measures 58
isolation distances 57, 58f
objective and simulation plan 56
regional crop proportions 56–57
local measures 53–54
buffer zones vs. harvest discarding 54
insufficiency of 54
objective and simulation plan 53–54
model analysis and evaluation 50
Ms8 Rapeseed 505f
Ms8 x RI3 Rapeseed 505t
perspectives of the modelling and simulation study 58–59
potential for crossing and introgression 24f
pre-sowing seed admixture certified seed lots 52–53
effects of GM and non-GM seed lot characteristics 52
objective and simulation plan 52
reference assays 275, 276t see also endogenous reference gene system
acyl-acyl carrier thioesterase 276t
arginine decarboxylase 276t
at1g53101 0 osr mapping 276t
cruciferine 276t
high mobility group protein 276t
phosphophuryrate carboxylase 276t
RI3 Rapeseed 505t
screening table 373f
seeds 49
simulation methodology 51–58
objectives and simulation steps 51–52
pre-sowing seed admixture 52–53
T45 Rapeseed 504t
testing of transgenic mitigation 73
tilling and secondary seed dormancy in 72
transgenic mitigation 73
transmission of chloroplast DNA through hybridisation with wild relatives 66
varietal association (VA) OSR 27
varieties 53
cropping systems 53
gene flow between varieties in contrasted scenarios 53
objective and simulation plan 53
volunteers 27–28, 56, 204
GENESYS model 50, 51f
management to reduce adventitious presence 28
persistence and longevity 27
wild relatives 28
see also Brassica, canola and rapeseed
oligoxplex/multiplex PCR assays 335
oligoxplex PCR 334, 336–337, 361–362
oligoxplex PCR-AGE 337–338
oligoxplex PCR-CGE 340–346
oligoxplex PCR-CGE-LIF 342

Bertheau—Genetically Modified and Non-Genetically Modified Food Supply Chains: Co-Existence and Traceability

Bertheau_7785_bindex_main.indd 656 8/15/2012 2:21:35 PM
Index

personal injury 407
pest management 181
PFAR see publishable final activity report
PCR-CGE method 388
the Philippines 36, 288
Phosphoenolpyruvate carboxilase 276t
Phospholipase D 276t
Picrogreen 298t
PicoGreen fluorometric DNA quantification 297
pig feed 215
pig production, regulation of 425
piglet feed 234f
pizza, GM ingredients in 180
pJANUS-02-001 dual target plasmid 300, 388 see also calibrant, reference materials and CRM
PL73 Brevibacterium 513t
plant variety lists 289
Plant Variety Protection (PVP) certificates 299, 300, 392, 535
plastids 65
Plexor technology 319
Plus-Hybrid System 67 see also bioconfinement and biological containment

P
padlock ligation detection 361f
padlock ligation microarray system 335
Palmer’s pigweed 569
PANZEA 287
papaya 4, 521, 524, 526, 533
Paraguay 545, 606f
share of soybean harvest exported to the EU 27 606f
soybeans imported to EU 27 606f
parallel PCR screening 361
parallel semi-quantitative event-specific screening 351
parthenocarpy 68–69
patents 94, 97, 110
and plant breeders’ rights 94
payoffs 597f
base case extensive form game and theoretical payoffs 597f
base case payoffs 598f
PCR see polymerase chain reaction (PCR)
PCR amplification efficiency 389
PCR-CGE-SC 342
PCR forming unit (PFU) 313 see also most probable number
penalty costs 601
penta(5)-plex PCR-CGE-SC 344t
pentaplex PCR 342
performance characteristics 320–321
Perkin Elmer MultiPROBE II 326, 327

in large fragmented landscapes 79–87
in maize 79
model evaluation 50, 52, 82–83, 627
modelling regional pollen transport 81–83
atmospheric model 81
conclusions and perspectives 84–86
conservation equations for pollen 81–82
mapping regional pollen sources 82–83 results 85
simulated regional pollen dispersal 84
in sugar beet 39–40
plastid DNA transmission through 65–66
transmission of transgenes through 62
viability 82, 83, 84f, 86f
pollination 27, 30
see also cross-pollination
polymerase chain reaction (PCR) 150, 153, 162, 167, 303, 307, 309, 333, 334, 377, 389, 525
analysis of flint maize in Argentina 152
Anchor PCR 230
application to whole supply chains 9
and automatic downgrading strategies 172–173
automation of 327
detection of PCR products by hybridisation in array format 346–353
digital PCR combined with high-throughput nanofluidic QRT-PCR 311–313
DNA extraction and 389
efficiency and matrix influence 297–299
importance of the specificity and uniformity of reference PCR systems 274f
influence of DNA extraction method on efficiency of 298f
issues for stakeholders 220
multiplex universal PCR and array based detection 347f
properties of 355f
setup automation 326–327, 328
technologies for the detection of PCR products 337–353
polymerase chain reaction (PCR)-based methods
estimation uncertainty for 393–394, 395f
expression of uncertainty for 393
standardised results from 394f
polymerase chain reaction (PCR) forming unit (PFU) 313 see also MPN

Bertheau—Genetically Modified and Non-Genetically Modified Food Supply Chains: Co-Existence and Traceability

Bertheau_7785_bindex_main.indd 657
8/15/2012 2:21:35 PM
Index

pork 228, 231, 545, 546, 548, 550, 551, 552
pork feed 234f
Portugal 4, 178, 216f, 553, 584
post-market environmental monitoring (PME) 11, 630 see also general surveillance
potato metalo-carboxypeptidase inhibitor gene 277f
potato(es) 141, 143t, 274, 276t, 375f, 376f, 504f
pre-market environmental monitoring (PMEM) 11, 630
pre-packaged products
pre-audits 236
powdered milk 550
poultry 152, 153, 231, 424, 425, 545, 546, 550, 551, 552, 553, 554
processing of fresh 150
reference assays 277f
potato metalo-carboxypeptidase inhibitor gene 277f
TATA binding protein gene 277f
UDP glucose pyrophosphorilase gene 277f
pre-packed products
distribution of RRS (RoundUp Ready Soybean) percent in 250f
precautionary principle 7, 9, 12, 293, 448–451, 454, 620
precision 384
intermediate precision 384
repeatability 384
preparation of GM feed 250f
preparation of GG feed 250f
preparation of GMO feed 250f
preparation of non-GMO feed 250f
preparation of non-GM feed 250f
preparation of non-GM soybean 250f
preparations 150
precaution 150
precaution in GM breeding 282–283
precautionary measures 184–186
production chain 252
procurement practices 603
product testing 162
product segregation systems 184–186
product liability 409–411
property rights 205
process models 482
processes 150
assessments of 482–485
schematic overview of 482f
processing of fresh 150
product liability 409–411
precautionary measures 184–186
production chain 252
considering 251–252
viewed as a sequence of processes 482f
production costs 251–252
of GM and non-GM feed in Belgium 221–222
production location 122
property, damage to 406
proportionality 207, 408
protein meals 180, 215
public good attributes of GM and non-GM goods 196
Publishable Final Activity Reports (PFAR) 3
pure economic loss 407–408 see also losses
PVP certificates 96, 97, 98, 107
Q
QRT-PCR machines 327
quantitative duplex real-time PCR 339–340
with IPC 340
quantitative multiplex assays 361
quantitative PCR 222, 311, 334, 339, 377, 531
quality control material 311
quality control 311
quality control 311
quality assurance 311
quality control material 311
quality control 311
quantitative PCR 335, 379 see also GMO analysis, GM detection, matrix approach and unauthorised GMOs
quantitative real-time PCR 338–339
for detection of RoundUp Ready soybean in processed foods 339
quantitative GMO analysis 335
quantitative multiplex assays 361
quantitative oligoplex (real-time) PCR 339
quantitative real-time PCR (QRT-PCR) 307, 308, 328, 389
QUIZ (quantitation using informative zeros) 311
R
random sampling schemes 261, 263 see also sampling
rapeseed see Brassica, canola and oilseed rape
oil 118f, 119, 12t
raw materials 316
real-time PCR 298t, 318–321, 338–340
see also quantitative real-time PCR
applicability and cost 355
controlling the bias of 315–317
evaluation of different machines for GM quantification by 321–323, 324t
molecular basis of different chemicals 318–320
performance 355
properties of 355t
using high-throughput nanofluidic dynamic arrays 312–313
Recommendation 2004/787/EC 8, 9, 564
Recoverable Block of Function strategy 71, 72
Red Bull drink Case 450
redress 9, 10, 408, 412–413 see also compensation, insurance, liability and private insurance
liability and redress options for damage caused by GMOs 405–413
reference assays 273–274 see also endogenous reference gene system
beet 273, 275f, 276f
biological aspects when designing 279–280
breeding issues 282–283
core collections for testing of 280–289
definition of 278t
heatmap of endogenous and transgenic assays on a dynamic array 314f
legislation issues 283
maize 277t, 287
oilseed rape 276t
phyllogenetic relationship between crop and relatives 280–281
Index

potato 277
potential for cross-reaction in 286
practicability and cost effectiveness 321
practical issues 283
reliability of 274–277, 278
rice 276
selection of species for specificity testing of 285f
specificity testing 283
taxonomy and phylogeny of the beet complex 275f
taxonomic status of crops 280
technical requirements for testing 278–280
validation of 290
reference materials 299–300 see also calibrant, CRM and JRC-IRMM
method validation and 383–401 see also CRL-GMPP, EURL-GMPP and JRC-IHCP
system 274f, 278 see also calibrant, CRM, JRC-IRMM and reference assays
regional model (RM) 482–483
Registration Requirement for Genetically Modified Soybean and Genetically Modified corn 532
Regulation see also Directive, Legislation and Recommendation
Regulation (EC) No 50/2000 142
Regulation (EC) No 65/2004 496t
Regulation (EC) No 178/2002 8, 191, 223, 224, 422, 494, 595, 605, 608, 611, 615 see also General Food Law
goals of 178
principles and requirements of 142
Regulation (EC) No 183/2005 223, 224, 422
Regulation (EC) No 258/1997 142, 178 see also Novel Food and Ingredient Law
Regulation (EC) No 641/2004 496t, 498
Regulation (EC) No 757/2003 566
Regulation (EC) No 852/2004 224
Regulation (EC) No 882/2004 497t, 498, 499 see also National Reference Laboratories
Regulation (EC) No 1829/2003 177, 217, 273, 293, 304, 478, 493, 494, 495, 497, 498, 595
enactment of 142
GMO detection methods validated by the CRL under 499
and labelling of feed products 154, 178
publication and key provisions of 496t
Regulation (EC) No 1830/2003 142, 154, 177, 178, 203, 217, 246, 248, 293, 422, 496t, 611
Regulation (EC) No 1946/2003 497t
Regulation (EC) No 1981/2006 496t, 498
regulations 223, 406
private 611–612
regulatory and responsibility frames 7–8
regulatory frameworks 6
relative limit of detection (LOD) 343, 347 see also absolute limit of detection, limit of detection and LOD
relative LOD/LOQ 310 see also relative limit of detection
relative standard deviation 322 see also bias and measurement uncertainty
relative standard uncertainty (RSUA) 251, 252 see also bias and measurement uncertainty
reproducibility standard deviation 394 see also bias and measurement uncertainty
research 8, 229–230
programmes 3, 10–11, 288, 418
resources
activation 577
equity-oriented conception 575
exploitation of 574
ideal conception 575
intangible resources 574
making full use of 575–578
material resources 574
in the post-Fordist era 574–575
specification 577
in territories 574–575
utilitarian conceptions 575
see also genetic resources and germplasm
rice 4, 274, 327, 375f, 376f, 503t, 504t
American broken rice 622
cleistogamy 64 see also biocconfinement and biological containment
collections of 288
detection of sequence motifs in transgenic 379
LLRICE62 Rice 503t
LLRICE601 Rice 504t
reference assays 276 see also reference assays and endogenous reference gene/system
phospholipase D 276t
root specific gos9 276t
sucrose phosphate synthase 276t
screening table 373f
Senegalese rice 622
risk assessment 3, 435–436, 523, 627
according to the potentially applicable health measures 441
adaption to the evolution of the scientific evidence 437
carried out by WTO member states 437
credible risk 445–447
data representing the dominant opinion versus data representing a minority opinion 441–442
data to collect to carry out 441
evaluation of the possibility or probability of a risk 439–440
high-quality and relevant 437–438
minimum risk threshold 443
most recent available data 442–443
national and international research results 442
plausible risk 445–447
possible risk 445–447
precautionary measures 443–445
probable risk 445–447
quantitative and qualitative 437
reflecting real conditions of the real world 440–441
related to the precise anticipated risk 439
type of experts entrusted for 438
uncertainty level and 436
using as a simple alibi 436–437
risk perception 6–7
risks
dread risks 593
information about 208
uncertain risks 593
RNA transcript sequence analysis 380
Romania, estimated production of compound feed 216f
Rome Treaty 418, 563
root specific gos9 276f
Round Table on Responsible Soy (RTRS) 236
Roundup see also glyphosate
Roundup Ready soy (RRS) 93, 229, 247, 300, 301f, 338, 339
Roundup Ready soybean (RRS) 345f
Roundup Ready sugar beets 39
Russia 3, 35, 36
S
safety regulations or tort liability 207–208
and tort liability 208–209
Salmon Case 440, 441, 446
sampling 9, 499–514, 626, 627, 629
and analysis budget 253
assessment of sampling methods 472–477
development of approaches 259
feasibility of sampling schemes 261
### Index

- **Index**

  seed contamination 421
  - seed germination blocking 71
  - sugar beet 42, 44
  
  see also soybean seeds, bioconfinement, biological containment, GURT, T-GURT and V-GURT

  segregation 602, 605 see also coexistence and identity preservation

  costs for the feed manufacturer 220–223
  - at feed manufacturing level 219
  - and traceability between GM and non-GM supply chains of single crop and compound food/feed products, costs of 177–191

  regulations 591, 592, 603

  strategies 154t
  - spatial segregation 128, 155, 566–568
  - temporal/time strategy 128

  SENASA 609, 612

  sensitivity 308, 599–602

  sensitivity analysis 167–170

  outputs 168–170

  parameters 167–168

  scenarios 168

  *Sesamia nonagrioides* see Mediterranean corn borer

  - sheep 548, 553

  SIGMEA project 11, 23, 24t, 27, 29, 32, 86

  - silo bags 152

  - SIMQUANT (single molecule quantification) 311, 328, 388, 471

  - simulation parameters 600t

  - single crops, costs of segregation and traceability between GM and non-GM supply chains of compound food/feed products and 177–191

  - single laboratory validation 338, 385–386 see also collaborative validation of methods, CRL-GMFF, EURL-GMFF and JRC-IHCP

  - single molecule quantification (SIMQUANT) 311, 328, 388, 471

  - single nucleotide polymorphism (SNP) 317, 335, 357–358 see also ligase chain reaction and SNPlex

  - based assay 377

  - SISSI software 248, 249, 250, 251, 267

  - site fitness 466

  - Skiff, Jim 93

  - Slovenia 361

  - risk of admixture on farms 147

  - supply chains analysed 143t

  - small operators 430

  - SNP see single nucleotide polymorphism

  - SNPllex PADLOCK ligation microarray 357–361

  - SNPllex technology 360f see also ligase chain reaction

  - social benefits, of co-existence 591–593

  - social insurance 411

  - software see AMPE, decision support system, DEXI, GENESYS, KeSTE, MAPOD, OPACSA, Seedcalc, SISSI and WEKA

  - sorghum 67, 287

  - sound science 620

  - South Africa 4, 36, 230

  - South America 233, 235, 287, 550, 609

  - *see also* Argentina, Brazil, Latin America and Mexico

  - South Korea 36

  - *soy feed* 234t

  - *see also* pig feed; piglet feed

  - soy 276t, 427, 547 see also soya and soybean

  - Brazilian case study on traceability and segregation of non-GM soy 227

  - cost calculations in single and compound food/feed value chains 179f

  - for food case study 156

  - GM soy

  - in animal feed 253–255

  - price evolutions of 235f

  - GMO-free soy 550

  - GMO-free soy supply, containment policy 551

  - Roundup Ready soy 93, 229, 247, 300, 301t, 339

  - transportation of 480

  - soy meal, imported by EU 606t

  - soy oil, imported by EU 606t

  - soy sauce 533

  - *soya beans* see *soybeans*

  - *soybean elevators* 232–233

  - *soybean lecithin, DNA extraction from* 318

  - *soybean meal*

  - EU production of 216

  - *Lo-Pro* soybean meal 215

  - soybean oil, DNA extraction from 318

  - soybean seeds

  - availability of non-GM 89–112

  - concentration in the US soybean seed industry 97t

  - market share evolution for varieties of 96f

  - soybean supply chain 141

  - GMO labelling 536–538

---

**E**

- **E**

  - Bertheau_7785_bindex_main.indd 660

  - 8/15/2012 2:21:36 PM

  - Bertheau—Genetically Modified and Non-Genetically Modified Food Supply Chains: Co-Existence and Traceability

  - 660
Index

soybeans 143t, 153, 255, 375f, 376f, 507t, 508t, 511t, 605t
A2704-12 Soybean 507t
A5547-127 Soybean 511t
availability of non-GM soybean seeds in USA 99t
breeding activity 96–97
competitive challenges facing small breeders 107
cross-pollination and volunteers 146
demand for non-GM soybeans 92
DNA quantification methods soybean grain 298t
soybean milk 298t
DNA, soybean feed 298t
DP-305423-1 Soybean 507t
DP-356043-5 Soybean 508t
future of public research on soybean breeding 105
germplasm 97–98, 106–107
global competitiveness of 106
global market 90–91
GM soybeans in Mercosur countries 606–609
price evolutions of 234f
imported by EU 606t
imports into the EU 216
integration of GM traits in 110
intellectual property rights for plant breeders 94
Kumen 4500 103
mergers and acquisitions in the soybean seed industry 95
MON 04032-6 Soybean 507t
MON 89788 Soybean 508t
non-GM breeders
characteristics of varieties 100
future of 104–108
state universities 99–100
varieties released by state universities 100
non-GM market 91–92
non-GM seed breeders, and availability of non-GM seeds 98–100
non-GM soybean seeds in Argentina 102–104, 108–109
non-GM sulfonylurea herbicide-tolerant 421
patents and PVP certificates 96
production 90f
GM and non-GM planted areas in the USA 90f
of non-GM 91–94
Roundup Ready seeds 93
Roundup Ready soybean 345f
RRS soybean, uncertainty profile 396
sampling of 474
screening table 373f
share of soybean harvest exported to the EU 27
soybean industry leaders and availability of non-GM soybean varieties in the USA 107–108
soybean products in animal feed 215
soybean products used in animal feed 215
supply of non-GM varieties for general use 107t
varieties with IPRs 97
space, discontinuity and heterogenous 586 see also land
Spain 410
Bt maize in 127
cross-pollination study 25
cultivation of GM crops in 543
equipment sharing 147
estimated production of compound feed 216f
standard field sampling system 256
supply chains analysed 143t
transport and reloading of maize 148
transport and storage of maize 147
volunteers in maize 26
spatial segregation 566–568
species, definition of 278t see also
reference assays and endogenous reference gene/system
specificity 384
specificity testing 284–286
Spinacia oleracea 276t
stacked gene see gene stacking
standards 9, 294, 397, 406
Standing Commission for Feedstuffs 438
Standing Veterinary Committee (SVC) 438
starch maize supply chain 161–175
aim of model 162
batch control 165–166
batch scheduling 165
control systems 165
estimating GM content as percentage of DNA bearing the transgene 166
GM adventitious presence quantification 166–167
material flow and risks of commingling 162–163
model 483, 487
basic attributes for the 484f
model description 163–167
results and discussion 170–173
sensitivity analysis 167–170
outputs 168–170
parameters 167–168
scenarios 168
testing procedure 165
wet-milling process 163, 164
starch synthase 277t
statutory compulsory certification system 528
statutory optional certification and mark system 528
strict liability rules 412
Saueda vera 278t
Suber, John 93
sucrose phosphate synthase 276t
sugar 36, 185f
sugar beet 35–48, 143t, 145, 276f, 281, 286, 375f, 376f
accidental admixture of seed lots 39
admixtures in 41
co-existence costs in Germany and Denmark 183f
collection routes 45–46
consequences of co-existence for genetic resources 45
consequences of co-existence for genetic resources 45
consequences of co-existence for the cropping systems of 42–45
cost calculations in single and compound food/feed value chains 179t
cross-pollination and volunteers 147
cultivation of 37–38
description and domestication 36
expected benefits of GM 38–39
gene flow 35, 42–43
GENESYS-Beet model 43
generic proximity 37
GM plants pollinating wild beets 41
GM sugar beets 36
harvesting machines 45
herbicide resistance 44 see also case specific monitoring
marketplace 35–36
Owen cytoplasm 41, 45 see also bioconfinement and biological containment
phylogeny see 275f
plant breeding 38
plant selection scheme 41–42
pollen dispersal 39–40
post-harvest co-existence issues 45–46
pre-cultivation co-existence issues 39–42
production areas 35
proximity of GM and non-GM nurseries 40
recommendations by inter-professional organisations 44–45
reference assays 276f see also reference assays and endogenous reference gene/system
rotation 44
Roundup Ready sugar beets 39
RUR H7 Sugar beet 501t
screening table 373f
seed migration in 41
Index

Bureau of Food and Drug Analysis (BFDA) of the DOH 533
GM food labelling 533
GMO detection in 533
National Science and Technology Program for Agricultural Biotechnology (NSTPAB) 533
National Science Council (NSC) 533
Plant Variety and Plant Seed Act 533
regulatory framework of GMOs in 532–533
Taiwan Seed Improvement and Propagation Station (TSIPS) 533
TagMan probes 247, 320, 321, 328, 338
TATA binding protein gene 277t
TAXon, definition of 278t
TaqMan probes 247, 320, 321, 328, 338
TATA binding protein gene 277t
taxon, definition of 278t
Taiwan Seed Improvement and Propagation Station (TSIPS) 533
Territoriality 582–584
and the environment 584–585
historical dimension 582–583
territories see also land
co-existence in 580–585
community initiatives 586
at the core of a network of different social actors and partners 572–574
debate and governance 581–582
diversity 581
exploitation and specification of resources 575–577
geographical scale and governance 581–582
from the populations who live there and rural areas not restricted to agricultural populations 572
quality-oriented approach 587
resources in 574–575, 576
understandings 587
Thailand 36, 606
third countries 196
cost of co-existence and traceability of rapeseed oil 182t
cross-pollination study 25
extension of prescriptions 430
pest management 181
supply chains analysed 143t
SYBR Green 319, 321
T
T-GURT (trait-specific GURT) 70
Taiwan 521, 532–534
agricultural products traceability system 533–534
Bureau of Food and Drug Analysis (BFDA) of the DOH 533
GM food labelling 533
GMO detection in 533
National Science and Technology Program for Agricultural Biotechnology (NSTPAB) 533
National Science Council (NSC) 533
Plant Variety and Plant Seed Act 533
regulatory framework of GMOs in 532–533
Taiwan Seed Improvement and Propagation Station (TSIPS) 533
TagMan probes 247, 320, 321, 328, 338
TATA binding protein gene 277t
taxon, definition of 278t
TaqMan probes 247, 320, 321, 328, 338
TATA binding protein gene 277t
Taiwan Seed Improvement and Propagation Station (TSIPS) 533
Territoriality 582–584
and the environment 584–585
historical dimension 582–583
territories see also land
co-existence in 580–585
community initiatives 586
at the core of a network of different social actors and partners 572–574
debate and governance 581–582
diversity 581
exploitation and specification of resources 575–577
geographical scale and governance 581–582
from the populations who live there and rural areas not restricted to agricultural populations 572
quality-oriented approach 587
resources in 574–575, 576
understandings 587
Thailand 36, 606
third countries 196
cost of co-existence and traceability of rapeseed oil 182t
cross-pollination study 25
extension of prescriptions 430
pest management 181
supply chains analysed 143t
SYBR Green 319, 321
T
T-GURT (trait-specific GURT) 70
Taiwan 521, 532–534
agricultural products traceability system 533–534
tomato(es) 118t, 119, 141, 143t, 145
cost of co-existence of GMO and non-GM 156
cross-pollination and volunteers 147
price consumers willing to pay (WTP) 123
processing 150
supply chain in Belgium 150
tort law 207, 406, 407, 408–411, 412
tort liability 207–208 see also compensation, liability and redress
Touvet, Laurent 447
traceability – 178, 202–204, 371, 422, 602, 612, 628–629, 630
in Argentina and Brazil 426
assessment of products using traceability data 477–481
and co-existence in supply chains 215–241
cost of segregating wheat to conform to EU standards 595–596
in EU and Mercosur countries 610–611
EU legislation on GMO 494–495
exemption from traceability requirements 495
failure of 245
at feed manufacturing level 219
integration of Co-extra results in EU tools for 493–520
introduction of 3–20
management of 2 overview 628–629
political aims of 423–424
and segregation at feed manufacturing level 219–220
and separation at import 218
and segregation between GM and non-GM supply chains of single crop and compound food/feed products, costs of 177–191
and segregation systems 218–224
studies on aspects of systems of 596
as a technical issue 422–423
truck traceability 46
see also measurement uncertainty and sampling
traceability frame 8–9
traceability regulations 591, 592, 603
traders, in the EU and Mercosur countries 613–614
training courses 516
Transcontainer 10, 11
transcriptomics 380
transgenes 31
biological containment of 61 see also biocontainment and biological containment
Bertheau—Genetically Modified and Non-Genetically Modified Food Supply Chains: Co-Existence and Traceability
transmission of 61
transmission through pollen 62
see also gene flow and pollen dispersal
transgenic crops
apomixis 69–70 see also
biocontainment and biological containment
biological containment 61–77 see also
biocontainment and biological containment
auxotrophy 62
cell-lethal gene expression 63
flowering inhibition and complete sterility 62–63
introduction 61–63
position in plant life cycle 62f
chloroplast transformation 65–67
cleistogamy 63–64 see also
biocontainment and biological containment
flowering inhibition 63 see also
biocontainment and biological containment
male sterility 67–68 see also
biocontainment and biological containment
parthenocarpity 68–69 see also
biocontainment and biological containment
seed dormancy inhibition 72 see also
biocontainment and biological containment
seed germination blocking 70–72 see also
biocontainment and biological containment
seed shattering 70 see also
biocontainment and biological containment
transgene excision 64–65
transgenic mitigation 72–73
transmission of 61
see also GM crops
transgenic DNA 333
transgenic mitigation 72–73
Transmissible Spongiform Encephalopathy
(TSE) 436, 445, 446 see also
bovine spongiform encephalopathy (BSE)
transportation model 478–481, 487
attributes of 480f
evaluation of the bulk maize transport
by the 481f
plus-minus-1 analysis results 481f
selective explanation of the bulk maize transport 481f
structure of 479, 480f
Treaty of Amsterdam 439
Treaty of Maastricht 293
Treaty of Rome 418, 563
true ness 327, 384, 536

Index

U
UDP glucose pyrophosphorilase gene 277f
UGM (unauthorised GMOs) model 477–478, 479f, 481, 487
attributes 479f
Analytical Methods 478
Geographical Origin of the product 477
Logistics 477–478
Systems Used in previous stages of the supply chain 477
hierarchical structure of 477, 478f
unknown GMOs 367–380
Ukraine 35, 149, 553, 554, 555, 622
unauthorised GMOs (UGM) detection of 356, 378–379
qualitative detection of 378–379
quantitative detection of 379
sources of 368
uncertainty 398
in GMO sampling 245
profile 395–396
see also bias, GMO sampling strategies, measurement uncertainty and sampling
uncertainty, situation of 7, 12, 619, 621
understandings 580, 583, 584
uniformity testing 284, 286
of RA for maize 287
unit of measurement 516
United Kingdom 121, 122, 123, 124, 553, 620
demand for non-GM food 229
estimated production of compound feed 216f
Farm Scale Evaluation 10
imports 149
supply chains analysed 143f
United States of America 4, 35, 94, 209, 216, 231, 237, 545, 606t
attitudes towards GMOs in opinion polls 194–195
availability of non-GM soybean seeds in 89, 99f, 109
concentration in the soybean seed industry 97f
demand for non-GM food 229
demand for non-GM soybeans 109
future of public research on soybean breeding 105
GM and non-GM planted areas in the 90f
soybeans imported to the EU-27 606t
US National Plant Germplasm System (NPGS) 288
V
V-GURT (variety-level GURT) 70, 71f
see also biocontainment, biological containment, GURT and T-GURT
validation (of detection methods) 303, 383–385
 collaborative validation of methods 386–387
in-house validation 385
modularity 388–390

Bertheau—Genetically Modified and Non-Genetically Modified Food Supply Chains: Co-Existence and Traceability

Bertheau_7785_bindex_main.indd 663
8/15/2012 2:21:36 PM
Index

beet 42

value

wheat starch supply chain

wheat 143t, 215

W

Zea mays see maize and corn

zones 571

buffer zones 25, 26, 53, 54, 151, 152, 181, 189, 209, 226, 413, 418, 566, 583

compliance with 568

vs harvest discarding 54

see also club, cluster coexistence and dedicated production area 124