# Contents

*List of Contributors*  
Foreword  
G. Riba, Vice-Chairman of INRA

**Part 1: Introduction**

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

**Part 2: Managing Gene Flow**

2 Contributions of Pollen and Seed to Impurity in Crops – A Comparison of Maize, Oilseed Rape and Beet  
*G.R. Squire, J. Lecomte, A. Hüskens, J. Soukup, A. Messéan*  
2.1 Introduction  
2.2 Maize  
2.3 Oilseed Rape  
2.4 Beet  
2.5 Comparison of Species Based on Plant Traits  
References

3 Co-Existence Issues of GM Sugar Beet  
*H. Darmency*  
3.1 Introduction  
3.2 Sugar Beet in the World  
3.3 Overview of Sugar Beet Biology and Agronomy  
3.4 Pre-cultivation Co-existence Issues  
3.5 Consequences of Co-existence for the Cropping System in a Region  
3.6 Consequences of Co-existence for the Genetic Resources  
3.7 Post-harvest Co-existence Issues  
3.8 Conclusion  
References
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
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
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
B. Lecroart, 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
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
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 215
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 245
R. Onori, J. Šuštar-Vozlič, G. Bellocci, G. Berben, A. Blejec, C. Brera, Z. Čergan (Deceased),
M. Debeljak, M. De Giacomo, M. De Vivo, T. Esteve, E. Janssen, P. Kozjak, F. Leprince,
R. Macarthur, A. Malcevschi, N. Marmiroli, V. Meglič, E. Melé, J. Messeguer, M. Miraglia,
A. Nadal, R. Oger, E. Palmaccio, M. Pla, V. Planchon, E. Prantera, K. Rostohar, B. Vrščaj
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 273
I. Taverniers, N. Papazova, T. Allnutt, S. Baumler, Y. Bertheau, T. Esteve, R. Freyer,
K. Gruden, B. Kuznetsov, J. Luis La Paz, A. Nadal, M. Pla, J. Vojvoda, D. Wulff, D. Zhang
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 293
M. Van den Bulcke, G. Bellocci, G. Berben, M. Burns, K. Cankar, M. De Giacomo,
K. Gruden, A. Holst-Jensen, A. Malcewsky, M. Mazzara, R. Onori, N. Papazova,
E. Parlouer, I. Taverniers, S. Trapmann, D. Wulff, D. Zhang
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 353
19.4 High Grade Multiplex Approaches 357
19.5 Conclusions 361

References 362

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. Bellocci, 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
References 398

#### Part 5: Legal Regimes, Liability and Redress Issues

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
   **M.-A. Hermitte, S. Anvar, M. Bonin, N. Bargues, G. Canselier, S. Desmoulin, A. Langlais, J.C. Varela**
   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 Arbitrator 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

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*

- Overview of EU Legislation on GMOs
- Achievements in the EU Harmonisation of GMO Analysis
- Challenges Ahead
- Conclusion

References

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


- Introduction
- People’s Republic of China
- Korea
- Taiwan
- Japan
- Conclusion

References

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

*R. Layadi*

- Introduction
- The GMO-free Regions Network
- The Feed Question: A Major Issue for Regional Agriculture
- GMO-free Agriculture, a Vital Issue for Regions
- Getting a Solid Strategic and Tactical Background: Lessons from the Cold War
- An Essential Question: Who Decides On the Definition of A Market?

References

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

*E. Glon*

- Introduction
- EU Scenarios for the Co-Existence of GM and Non-GM Crops
- Dedicated Areas – A Geographical Analysis
- A Few Lines for Thought with Regard to Co-Existence in Territories
- Conclusion

References

30 Segregating Supply Chains: a Cost–Benefit Perspective

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

- Introduction
- Social Benefits of Co-Existence
- Consumer Valuation of GMO-free Foods
- Background on Developments in North American Wheat
- Costs of Segregating Wheat to Conform to EU Traceability Standards
- Contract Mechanisms to Facilitate Co-Existence
- Summary and Implications
- Conclusion

References
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
A colour plate section falls between pages 314 and 315