

Contents

Contributors	xi
Foreword	xv
Preface	xvii

I

Nanotechnology Applications for food safety monitoring

1. Nanotechnology applications for food safety: Benefits and risks

Claudia Girthie John Britto, Amal Dhivahar Sahaya Antony John, Archanna Jayakumar, Pavidharshini Selvasekaran, Ramalingam Chidambaram, Haotian Zheng

1.1	Introduction	3
1.2	Nanosensors in food safety	4
1.3	Nanocomposites in food safety	10
1.4	Nanomaterials	12
1.5	Nanoencapsulation	15
1.6	Nanoemulsions	16
1.7	Nanocoating	17
1.8	Nanoclusters	18
1.9	Risks associated with nanotechnology	20
1.10	Conclusion	21
	Acknowledgment	21
	References	22

2. Surface-enhanced Raman spectroscopy for food quality and safety monitoring

Rajapandiyan Panneerselvam, Selvaraju Kanagarajan, Arunima Jinachandran

2.1	Introduction	31
2.2	Basic principles and a short history of surface-enhanced Raman spectroscopy	32
2.3	Different types of SERS substrates	36
2.4	Applications	39
2.5	Summary and outlook	45
	References	47

3. Applications of metal oxide nanoparticles in food safety

Gurjeet Kaur, Saloni Sharma, Akash Deep

3.1	Introduction	55
3.2	Metal oxide nanoparticles as antibacterial agents	57
3.3	Metal oxide nanoparticles in smart packaging	62
3.4	Conclusion	65
	Acknowledgments	66
	References	66

4. Identification and characterization techniques for engineered nanomaterials in food

Jayasree Joshi T., Harsha V., Anitha Krishnan V.C., Asha Ashok

4.1	Introduction	71
4.2	Characteristics of engineered nanomaterials	72
4.3	Techniques for the identification and characterization of engineered nanoparticles	74
4.4	Techniques for the separation of engineered nanoparticles	80
4.5	Challenges in the determination of ENMs	84
4.6	Conclusion	85
	References	85

5. Nanotechnology-oriented sensors for the quick recognition of foodborne microbes and pathogens

Lavanya Devraj, Abhirami Panoth, Madineni Yogitha Chowdary, Payel Ghosh

5.1	Introduction	93
5.2	Selection criteria for nanoparticles for application in biosensors	94

- 5.3 Detection of foodborne pathogens originated from bacteria 101
- 5.4 Detection of microbial agents through nanodiagnostic perspective 102
- 5.5 LOC assays (lab on chip) 103
- 5.6 Nanoparticle-based assays 104
- 5.7 Nanomaterial materials are used for the fabrication of biosensors for detecting foodborne pathogens 104
- 5.8 Present status and future prospectus of nano biosensors 108
- 5.9 Conclusion 109
- References 109
- 6. Functionalized porphyrin-based nanocomposites as prospective materials for food safety sensors**
- Ambika Bhardwaj, Saurav Kumar, Anupma Sharma, Sudeshna Bagchi
- Introduction 113
- 6.1 Chemical and biochemical reaction pathways 113
- 6.2 Porphyrin-based nanomaterials 118
- 6.3 Sensor design and integration 122
- 6.4 Applications as food safety sensors 124
- 6.5 Conclusions 130
- References 130
- 7. Shellac: A natural lipid polymer for food safety and quality monitoring**
- Saurav Kumar, Lubhan Cherwoo, Nishtha Puri, Anupma Sharma, Nandkishore Thombare, Amol P. Bhondekar
- 7.1 Introduction 135
- 7.2 Background 136
- 7.3 Shellac for nanotechnology in the food industry 142
- 7.4 Films and packaging 142
- 7.5 Edible coatings and shelf-life enhancer 142
- 7.6 Quality enhancer and preservation 145
- 7.7 Food nanosensors 145
- 7.8 Food safety and other applications 146
- 7.9 Market potential of shellac in food safety and quality monitoring 146
- 7.10 Commercial presence of shellac 150
- 7.11 Scopes and future application 151
- References 151
- 8. Detection of food toxins, pathogens, and microorganisms using nanotechnology-based sensors**
- Gayathri Vijayakumar, Surya Arcot Venkatesan, Vishal Amith Kannan, Suparna Perumal
- 8.1 Introduction 155
- 8.2 Microbial food toxins 156
- 8.3 Pathogens 158
- 8.4 Other contaminants 159
- 8.5 Nanosensors 161
- 8.6 Nanosensors in detection of toxins and pathogens 165
- 8.7 Future prospects 166
- 8.8 Conclusion 167
- References 167
- 9. Nanotechnology applications and implications in food industry**
- Arun Sharma, Nagarajan J, Krishna Gopalakrishnan, Vikrant Bodana, Anurag Singh, Pramod K. Prabhakar, Rajat Suhag, Ritesh Kumar
- 9.1 Introduction 171
- 9.2 Nanomaterials in food industry 172
- 9.3 Safety and toxicological aspect of nanotechnology 178
- 9.4 Conclusion 180
- References 181
- 10. Nanosensors for the detections of foodborne pathogens and toxins**
- Shivangi Mishra, Shruti Mishra, Aishwarya Dhiman, Rakhi Singh
- 10.1 Introduction 183
- 10.2 Food borne pathogen and toxins 184
- 10.3 Factors responsible for the foodborne diseases 186
- 10.4 Traditional and modern methods of detection of food borne pathogens 186
- 10.5 Nanosensors 189
- 10.6 Conclusion 198
- References 199

11. Metal-organic framework-based nanomaterials for the optoelectrochemical detection of food contaminants

Saloni Sharma, Gurjeet Kaur, Akash Deep

- 11.1 Introduction 205
- 11.2 Occurrence and effects of food contaminants 207
- 11.3 Metal organic frameworks 212
- 11.4 Conclusion and future perspectives 217
- Acknowledgments 218
- References 218

12. Nanoemulsions: Nanotechnological approach in food quality monitoring

Anurag Nain, Divya Bajpai Tripathy, Anjali Gupta, Rashmi Dubey, Kuldeep, Anurag Singh

- 12.1 Introduction 223
- 12.2 General constitution of nanoemulsions 225
- 12.3 Physical properties of nanoemulsion 226
- 12.4 Nanoemulsion preparation 227
- 12.5 Nanoemulsions characteristics 232
- 12.6 Applications of nanoemulsions in the food industry 234
- 12.7 Conclusions and future prospects 235
- References 236

II

Nanotechnology Applications for food quality monitoring

13. Nanotechnology: A new approach to advanced food packaging

Shuting Huang, Varee Tyagi, Bhaswati Bhattacharya, Yixiang Wang

- 13.1 Introduction 241
- 13.2 Packaging nanomaterial with improved performance 242
- 13.3 Nanotechnology in active packaging 247
- 13.4 Nanotechnology in intelligent packaging 252
- 13.5 Food packaging-related safety concerns 257
- 13.6 Future prospects 258
- References 259

14. Nanotechnology applications for quality determination of RTE and packaged food

Ajay V. Chinchkar, Anurag Singh, Meenatai G. Kamble, Pramod K. Prabhakar, Murlidhar Meghwal, Arun Sharma

- 14.1 Introduction 265
- 14.2 Packaging concepts for ready-to-eat food: recent progress 266
- 14.3 Application of nanotechnology in RTE foods 267
- 14.4 Nanotechnology for nanosensors and nanobiosensors in food processing and its applications in food quality monitoring 269
- 14.5 Role of nanotechnology in active, intelligent, and smart packaging 275
- 14.6 Shortcomings of nanomaterial 281
- 14.7 Conclusion 281
- References 282

15. Nanotechnology-based sensors for shelf-life determination of food materials

Ajita Tiwari, Rahul Islam Barbhuiya, Kshirod Kumar Dash

- 15.1 Introduction 289
- 15.2 Nanotechnology-based primary technologies of a packaging system 291
- 15.3 Nanotechnology-based sensors and assays used for the detection of small organic molecules, gases, and microorganisms 293
- 15.4 Nanomaterial utilization in optical and electrochemical sensors for food analysis 295
- 15.5 Conclusion and future aspects 297
- References 298

16. Nanotechnology applications in food packaging

Janani Muthukumar, Geetanjali Shukla, Shalini Bhattacharyya, Richa Pathak, Lokesh Kumar, Ramalingam Chidambaram

- 16.1 Introduction 301
- 16.2 Nanoforms in food packaging 302
- 16.3 Food nanopackaging 312
- 16.4 Conclusion 317
- Acknowledgment 317
- References 317

17. Applications of nanotechnology in food sensing and food packaging

Pinku Chandra Nath, Nishithendu Bikash Nandi, Ajita Tiwari,
Joydeep Das, Biplab Roy

- 17.1 Introduction 321
- 17.2 Food analysis sensors based on nanotechnology 322
- 17.3 Nanomaterials in biodegradable food packaging 326
- 17.4 Active and functional nanopackaging 331
- 17.5 Safety consideration 334
- 17.6 Conclusion 335
- 17.7 Summary and future prospects 335
- Abbreviations 336
- References 336

18. Quality assurance of packaged food using nanotechnology

Janani Muthukumar, Sanjusree Kumar, Nisha Arunachalam,
Lokesh Kumar, Ramalingam Chidambaram

- 18.1 Introduction 341
- 18.2 Food packaging: traditional and conventional 343
- 18.3 Nanotechnology in food packaging 345
- 18.4 Nanotechnology in quality determination 350
- 18.5 Conclusion 364
- References 367
- Further reading 372

19. Silica-based nanocomposites for preservation of post-harvest produce

Swapnil Barve, Nishant Veer Vikram Singh, Chiragkumar Rasbhara,
Parthendu Sarkar, Peerzada Gh. Jeelani, Abdel-Tawab Mossa,
Ramalingam Chidambaram

- 19.1 Introduction 373
- 19.2 Post-harvest loss 376
- 19.3 Silica-based bionanocomposites for post-harvest produced preservation 379
- 19.4 Applications 387

- 19.5 Future aspect 389
- 19.6 Conclusion 389
- References 390

20. Biodegradable polymers/silica nanocomposites: Applications in food packaging

Anwesha Mukherjee, Sangita Panda, Peerzada Gh. Jeelani,
Abdel-Tawab Mossa, Ramalingam Chidambaram

- 20.1 Introduction 395
- 20.2 Properties of biodegradable polymers and application in food packaging 396
- 20.3 Role of silica-nanoparticles for food packaging 399
- 20.4 Biodegradable silica nanocomposites 400
- 20.5 Various types of silica nanocomposites for food packaging with its applications 401
- 20.6 Future aspects for food packaging 409
- 20.7 Conclusion 410
- Acknowledgement 410
- References 411

21. Role of nanotechnology in food supply chain

Bababode Adesegun Kehinde, Anil Panghal, Priya Bishnoi,
Navnidhi Chhikara

- 21.1 Introduction 415
- 21.2 Nanotechnology and food supply chain 417
- 21.3 Nanotechnology in packaging 417
- 21.4 E-nose (electrical nose) 422
- 21.5 E-tongue (electrical tongue) 423
- 21.6 LF NMR and MRI system (moisture detection) 424
- 21.7 RFID tags 424
- 21.8 Sensors 424
- 21.9 Microbial detection 425
- 21.10 Nanotechnology and safety concerns 426
- 21.11 Conclusion 427
- References 428

22. Nanoencapsulation of antimicrobial agents and antimicrobial effect of silver nanoparticles

Chandan Krishnamoorthy, Pratik Chatterjee, Utpalendu Paul, Subhadeep Banerjee, Lokesh Kumar, Ramalingam Chidambaram

- 22.1 Introduction 435
- 22.2 Nanoencapsulation and its preparing methods 437
- 22.3 Types of nanoencapsulation systems 442
- 22.4 Antimicrobial effect nanoparticles 448
- References 452

23. Nanotechnology applications for food traceability

Divya Aggarwal, Rubeka Idrishi

- 23.1 Introduction 457
- 23.2 What is a food traceability system? 458
- 23.3 Nanosensors in food traceability 459
- 23.4 Role of nanotechnology in assessing food traceability 462
- 23.5 Nanotechnology in food fraud and adulteration 464
- 23.6 Consumer's and industry perception toward accepting nanotechnology in food traceability systems 465

- 23.7 Safety regulations and legislations for nanotechnology in food traceability 466
- 23.8 Novel trends and future perspectives 466
- 23.9 Conclusion and future prospects 468
- References 468

24. Applications of nanotechnology in food sector: Boons and banes

Shibasini Murugan, Vijay Karuppiah, Kavitha Thangavel, Sivasakthivelan Panneerselvam

- 24.1 Introduction 473
- 24.2 Overview of nanotechnology in the food sector 475
- 24.3 Nanotechnology in food materials 476
- 24.4 Nanotechnology in food production 477
- 24.5 Nanotechnology in food packaging 479
- 24.6 Hazards of nanomaterials 485
- 24.7 Conclusion 486
- Declarations 486
- Acknowledgments 487
- Abbreviations 487
- References 488

Index 493