Contents

List of contributors xi

1 Microbial secondary metabolites and their roles in biocontrol of phytopathogens **1**

V.I. Gwa and E.J. Ekefan

1.1 Introduction 1
1.2 Primary and secondary metabolites 2
1.3 Biological control agents 2
1.4 Fungal secondary metabolites 3
1.5 Genus *Bacillus* for biological control of phytopathogens 13
1.6 Genus *Pseudomonas* for biological control of phytopathogens 15
1.7 Conclusion 21
Acknowledgment 21
Conflict of Interest 21
References 22

2 Microbial metabolites with biological control activity **31**

Amelia C. Montoya-Martínez, Valeria Valenzuela-Ruiz, Ana María García-Montelongo, Roel Alejandro Chávez-Luzania, Fannie I. Parra-Cota and Sergio de los Santos-Villalobos

2.1 Introduction 31
2.2 Lytic enzymes 32
2.3 Antibiotics 34
2.4 Endotoxins 36
2.5 Siderophores 37
2.6 Bacteriocins 38
2.7 Volatile organic compounds 40
2.8 Perspectives 42
2.9 Conclusion 43
References 43

3 Role of rhizobial metabolites in control of soil-borne phytopathogenic fungi **51**

Rashmi Rekha Boruah and Aku Hage

3.1 Introduction 51

3.2 *Rhizobium*—legume interactions and biological nitrogen fixation 52
3.3 Rhizobia as a biocontrol agent against fungal phytopathogens 54
3.4 Biocontrol mechanism of rhizobia 56
3.5 Future prospective and conclusion 59
References 60
Further reading 65

4 Agriculturally important microbial secondary metabolites 67

Sonia Sethi

4.1 Introduction 67
4.2 Metabolites from microbes 68
4.3 VOCs in microbe—microbe interaction 69
4.4 Bacterial metabolites with insecticidal properties 76
4.5 Conclusion 77
References 77

5 Microbial metabolites and bioactive compounds from fermented fruit waste 83

Dimas Rahadian Aji Muhammad, Viet Bao Nguyen, Phuong Hong Le and Adhitya Pitara Sanjaya

5.1 Introduction 83
5.2 Potential use of fruit waste 84
5.3 Fermentation of fruit waste stream 89
5.4 Improvement of extractable bioactive compounds 95
5.5 Extraction of bioactive compounds 96
5.6 Encapsulation of bioactive compounds 106
5.7 Conclusion 108
References 108

6 Fungal extracellular carboxylic acids associated with ore mining: a wide perspective for the future 123

Ellen C. Giese, Leonard S. Santos and Ana Carolina O. Santana

6.1 Introduction 123
6.2 Citric acid 124
6.3 Itaconic acid 125
6.4 Fumaric acid 126
6.5 Malic acid 127
6.6 Gluconic acid 131
6.7 Lactic acid 132

6.8 Oxalic acid 133
6.9 Alpha-ketoglutaric acid 135
6.10 Filamentous fungi as bioleaching agents 137
6.11 Solubilization mechanisms in biohydrometallurgy 140
6.12 Fungal organic acids in the hydrometallurgy of atmospheric leaching of laterites 141
6.13 Conclusion 144
References 144

7 Chitinase enzyme: sources and application 151
Akanksha Srivastava and Suchi Srivastava

7.1 Introduction 151
7.2 Structure of chitinase 152
7.3 Sources of chitinase 152
7.4 Chitinase production 155
7.5 Applications of chitinases 156
7.6 Conclusion 160
References 160

8 Microbial mannanases and their biotechnological applications 165
Rahul Kumar Suryawanshi and Naveen Kango

8.1 Introduction 165
8.2 Mannan degrading enzymes and their sources 166
8.3 Mode of action of mannanases 167
8.4 Microbial source of β-mannanase 167
8.5 Biotechnological applications of β-mannanases 171
8.6 Conclusion 177
References 177

9 Kojic acid: history, properties, biosynthesis, and applications 183
Abdel-Naser A. Zohri, Ghada Abd-Elmonsef Mahmoud and Nahla A. Kamal-Eldin

9.1 History 183
9.2 Physico-chemical properties of kojic acid 183
9.3 *Aspergillus* as a producer of kojic acid 184
9.4 Derivatives of kojic acid 189
9.5 Applications of kojic acid 190
9.6 Future directions and concluding remarks 193
References 193

10 Bioactive peptides derived from milk: formation and functional benefits 201

Ismail Tijjani Kabwanga, Sebnem Ozturkoglu-Budak and Kavindra Kumar Kesari

10.1 Introduction 201
10.2 Mechanisms for bioactive peptide formation 202
10.3 Functional effects of milk-derived bioactive peptides 203
10.4 Lactic acid bacteria (LAB) as source of bioactive peptides 209
10.5 Conclusion 212
References 212

11 Insights into the challenges and resolutions in the bacterial fermentation process 219

Sonali Biswas, Shatarupa Biswas, Udisha Sarkar and Arindam Mitra

11.1 Introduction 219
11.2 Brief history of fermentation 220
11.3 Bacterial fermentation processes 221
11.4 Challenges in bacterial fermentation processes 225
11.5 Conclusions 228
References 228

12 Microbial protease: an update on sources, production methods, and applications 233

Chetan Kumar Dubey, Jitendra Mishra, Abhishek Nagar, M.K. Gupta, Archana Sharma, Subham Kumar, Vaibhav Mishra and Haushila Prasad Pandey

12.1 Introduction 233
12.2 Classification of protease 234
12.3 Source of microbial protease 235
12.4 Production of protease 238
12.5 Stability of protease 242
12.6 Application of microbial protease enzyme 243
12.7 Conclusion 250
References 250

13 Microbial metabolites with anticancerous properties 261

Nalini Kurup, Swati Patil, Nikhil Rajnani and Rujuta Gandhi

13.1 Introduction 261
13.2 Algae metabolites 264
13.3 Bacterial metabolite 268
13.4 Fungal metabolites 272

13.5 Protozoal metabolites 277
13.6 Regulatory concerns 278
13.7 Conclusion 279
References 280
Further reading 285

14 Underexplored groups of soil microorganisms: a treasure house for bioactive metabolites with therapeutic value 287

Rita Lakkakul, Shreya Reddy, B.A. Mehere and Dinesh Wadikar

14.1 Introduction 287
14.2 Lineages of novel soil bacteria producing secondary metabolites 289
14.3 Biosynthetic gene clusters for secondary metabolites production by the soil microorganisms 292
14.4 Bioactive compounds from soil bacteria and their therapeutic value 293
14.5 Underexplored soil fungi produce novel bioactive secondary metabolites 298
14.6 Conclusion 301
References 301

15 Use and applications of bioactive microbial metabolites in human health 309

Sunita Singh, Poonam Verma and Pratibha Kumari

15.1 Introduction 309
15.2 Microbial metabolites 310
15.3 Sources of microbial metabolites 318
15.4 Application of bioactive microbial metabolites 319
15.5 New approaches for bioactive metabolite-based drugs discovery 324
15.6 Conclusion 325
References 326

Index *335*