

© The Chinese University of Hong Kong 1993

All Rights Reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from The Chinese University of Hong Kong.

ISBN 962-201-610-3

THE CHINESE UNIVERSITY PRESS
The Chinese University of Hong Kong
SHATIN, N.T., HONG KONG

Printed in Hong Kong by Nam Fung Printing Co., Ltd.

Contents

List of Contributors

Foreword

Preface

Part I MUSHROOM BIOLOGY - FUNDAMENTAL ASPECTS 1

1. Mushroom Biology: The Impact on Mushroom Production and Mushroom Products 3

SHU-TING CHANG

1. Introduction	3
2. Mushrooms and Mushroom Biology	4
3. Mushroom Science	10
4. Mushroom Biotechnology	14
5. Concluding Remarks: Learn from History	16
References	17

2. Identification, Names and Nomenclature of Common Edible Mushrooms 21

PETER K. BUCHANAN

1. Taxonomy is Fundamental to Mushroom Science	21
2. The Species Concept in the Basidiomycetes	21
3. Names of Commonly Cultivated Edible Mushrooms	22
4. 'Lists of Names in Current Use', Improving Stability of Names?	28
5. Recommendation	28
References	29

3. Control of Pattern and Form in Mushroom Morphogenesis 33

DAVID MOORE

1. Introduction	33
2. Patterns in Theory	33
3. Patterns in Time	34
4. Patterns in Space	36
5. Patterns in Experiment	38
References	38

4. Physiology, Cytology and Genetics of Mushrooms	41
SIU WAI CHIU	
1. Introduction	41
2. Developmental Plasticity - A Challenge to Taxonomists	41
3. Cytogenetics - A Challenge to Mushroom Breeders	42
4. Modulating Mushroom Growth & Development - A Challenge to Farmers	44
5. Conclusion	45
References	45
5. Molecular Genetic Analysis of Diversity in Populations of Edible Mushrooms	49
DANIEL J. ROYSE, BRITT A. BUNYARD AND MICHAEL S. NICHOLSON	
1. Introduction	49
2. Methods Used in Fungal Molecular Genetics	49
3. Outlook	52
References	52
6. New Perspectives on the Genetics of <i>Pleurotus</i>	55
J.F. PEBERDY, AIDAH M. HANIFAH AND JIAN-HUA JIA	
1. Introduction	55
2. Mating Type Analysis in <i>Pleurotus sajor-caju</i>	57
3. Breeding Strategy in <i>Pleurotus sajor-caju</i>	58
4. Mating Interactions Between <i>Pleurotus</i> Species	58
5. Molecular Karyotypes in <i>Pleurotus</i>	61
6. Future Outlook	61
References	61
7. Genetics and Breeding of Spore-Deficient Strains in <i>Agrocybe cylindracea</i> and <i>Lentinus edodes</i>	63
S. MURAKAMI	
1. Introduction	63
2. Sporeless Mutant of <i>Lentinus edodes</i>	63
3. Breeding Spore-deficient Strains of <i>Agrocybe cylindracea</i>	65
References	68

PART II. MUSHROOM CULTIVATION AND BIOCONVERSION TECHNOLOGY	71
8. Biology and Cultivation Technology of <i>Volvariella volvacea</i>	73
SHU-TING CHANG	
1. Introduction	73
2. Physiological Nature	74
3. Prospects for Genetic Manipulation in the Breeding of <i>Volvariella</i> Mushrooms	78
4. Cultivation	80
5. Utilization of Waste Tea-Leaves in the Preparation of Spawn	81
6. General Remarks	81
References	82
9. Interactions Between Supplementation, Fructification-Surface and Productivity of the Substrate of <i>Pleurotus</i> Spp.	85
J.I. LELLEY AND A. JANßEN	
1. Introduction	85
2. Materials and Methods	86
3. Results	87
4. Conclusions	91
References	91
10. Indoor Composting: General Principles and Large Scale Development in Italy	93
J. LABORDE, G. LANZI, B. FRANCESCUTTI AND E. GIORDANI	
1. Historical Background	93
2. Requirements for Composting Indoor	97
3. Indoor Composting Facilities	103
4. Comparative Description of Each Process	104
5. Discussion	107
6. Conclusion	108
References	108
11. An Abbreviated Mushroom Composting System Aided by an Accelerator	115
N.G. NAIR AND G. PRICE	
1. Introduction	115
2. Background to the AAC Process	115
3. The AAC Process	117
4. Conclusions	119
References	121

12. Reconstruction of the Mushroom Industry in Poland	123
K. SZUDYGA	
1. Polish Mushroom Industry	123
2. Strategy Plan	124
3. Solution	125
4. Preparation of Compost	125
5. Extension	126
References	127
13. Biology of Artificial Log Cultivation of <i>Auricularia</i> Mushrooms	129
X.C. LUO	
1. Introduction	129
2. Classification and Natural Distribution	129
3. Mating Type and Monokaryotic Fruit Body	129
4. Conditions of Growth and Development	130
5. Cellulase and Ligninase Activities and Rate of Degradation of Cultivation Substrate	131
6. The Five Stages of Fruit Body Development	131
7. Artificial Log Cultivation of <i>Auricularia</i> Mushrooms	131
References	132
14. Progress of Cultivation Technique of <i>Agaricus bisporus</i> in China	133
Z.S. WANG AND H.C. WANG	
1. Introduction	133
2. Research on a New Technique of Composting (1978-1985)	133
3. Breeding of Strains with High Productivity and Good Quality for Canning Special Purpose (1983-1992)	134
4. Design and Application of a Simply-Constructed Growing House Using Polyethylene (P.E.) Film (1988-1993)	138
References	139
15. Fungal- and Substrate-Associated Factors Affecting the Growth of Individual Mushroom Species on Different Lignocellulosic Substrates	141
J.A. BUSWELL, Y.J. CAI AND S.T. CHANG	
1. Introduction	141
2. Lignocellulolytic Enzyme Production by <i>L. edodes</i> , <i>P. sajor-caju</i> and <i>V. volvacea</i>	142
3. Effect of Lignin-derived Phenolic Monomers on Mushroom Growth	143
4. Effect of Tannin Derivatives on Mushroom Growth	146

5. Discussion	146
References	148
16. Conversion of Lignocellulosics into Animal Feed with White-rot Fungi	151
FRANTISEK ZADRAZIL	
1. Introduction	151
2. Ecological Background of Conversion of Lignocellulosics into Enriched Animal Feed	152
3. Scale-up of Solid State Fermentation	155
4. Conclusions	159
References	160
17. Physiology and Biochemistry of Lignocellulose Utilization by <i>Pholiota nameko</i>	163
G.L. YANG, L. MA, Y.W. YANG AND Y. WANG	
1. Introduction	163
2. Materials and Methods	163
3. Results and Discussion	164
References	168
Part III POST-HARVEST PROCESSING AND QUALITY CONTROL	169
18. Mushroom Senescence: Its Mechanism and Control	171
K.S. BURTON	
1. Introduction	171
2. Carbon Catabolism	171
3. Nitrogen Metabolism	172
4. Tissue Browning	173
5. Cell Structure and Tissue Partitioning	173
6. Modified Atmosphere Packaging	174
References	174
19. Selected Cultural and Harvest Practices to Improve the Quality and Shelf Life of <i>Agaricus</i> Mushrooms	177
R.B. BEELMAN, M.B. MIKLUS, J.-L. MAU, S.O. AJLOUNI AND S.S. SIMONS	
1. Introduction	177
2. Treatment of Irrigation Water with Calcium Chloride	177
3. Influence of Maturity at Harvest	178

4. Influence of Stipe Trimming at Harvest	178
References	184
20. Contamination of Mushrooms and Canned Mushrooms	185
CHAO-WEI LI, ZHONG-LIANG WU, ZHONG-CHANG ZHANG, SHOU-SONG LI AND WEI-LING CHENG	
1. Introduction	185
2. Possible Sources of Contamination and Preventative Measures	185
3. Non-Specific Reaction of the TECRA Kit	186
4. Specificity of Four Commercial Screening Kits	186
5. Detection of SET in Mushroom Products Using Kits	187
6. Investigation of Potential Sources of SET in Contamination in China	188
7. Conclusions	190
References	191
21. Behavior and Serological Identification of Staphylococcal Enterotoxin in Thermally Processed Mushrooms	193
R.W. BENNETT, T. SULLIVAN, K. CATHERWOOD, L.J. LUKEY AND N. ABHAYARATNA	
1. Introduction	193
2. Recovery and Serological Identification of Enterotoxin in Canned Mushrooms	194
3. Serological Identification of Staphylococcal Enterotoxins	195
4. Heat and Chemical Denaturation of Toxin	196
5. Urea Renaturation of Toxin	196
6. Serological Degradation of Heat-Altered Enterotoxin	200
7. Conclusion	204
References	206
22. Detection of Staphylococcal Enterotoxin in Mushrooms	209
M.S. BERGDOLL	
1. Introduction	209
2. Development of Detection Methods	209
3. Sensitive Detection Methods	210
4. Screening Kits	211
5. Case Study	212
6. International Collaboration for Development	213
References	213

Part IV NUTRITIONAL AND MEDICINAL ATTRIBUTES OF MUSHROOMS	217
23. Analysis, Digestibility and the Nutritional Value of Mushrooms	219
RALPH H. KURTZMAN, Jr	
1. Introduction	219
2. Labeling Laws	220
3. Anti-Nutritional factors	221
4. Vitamins	222
5. Feeding Experiments	222
6. Conclusions	224
References	224
24. Nutritional Importance of Mushrooms	227
H.S. GARCHA, P.K. KHANNA AND G.L. SONI	
1. Introduction	227
2. Comparative Nutritional Analysis of <i>Agaricus bisporus</i> and <i>Pleurotus</i> spp.	228
3. Nutritional Analysis of <i>Pleurotus florida</i>	229
4. Nutritional Evaluation of <i>A. bisporus</i> and <i>P. florida</i>	230
5. Comparison of the Digestibility of <i>A. bisporus</i> and <i>Pleurotus</i> spp.	231
6. Fatty Acid Composition of <i>A. bisporus</i> and <i>P. florida</i>	233
7. Feeding Experiments	233
References	235
25. Diverse Biological Activity of PSK (Krestin), a Protein-bound Polysaccharide from <i>Coriolus versicolor</i> (Fr.) Quel.	237
HIROSHI SAKAGAMI AND MINORU TAKEDA	
1. Introduction	237
2. Chemical Properties	237
3. Induction of Antimicrobial Activity <i>in vivo</i>	238
4. <i>In vitro</i> Effects	239
5. Biological Activity of PSK Fractions	241
6. Conclusions	242
References	242
26. A New Biological Response Modifier - PSP	247
Q.Y. YANG, Y.J. HU, X.Y. LI, S.X. YANG, J.X. LIU, T.F. LIU, G.M. XU AND M.L. LIAO	
1. Introduction	247

2. Pharmacological Effects of PSP	248
3. Clinical Research on PSP	253
4. Discussion	256
5. Summary	258
References	258
27. Medical Aspects of Lentinan Isolated from <i>Lentinus edodes</i> (Berk.) Sing.	261
GORO CHIHARA	
1. Introduction	261
2. Lentinan as a Host Defence Potentiator (HDP)	261
3. Biological Activity of Lentinan	262
4. Mechanism of Action of Lentinan	262
5. Clinical Applications of Lentinan	263
6. Future Prospects for Lentinan	264
7. Conclusion	265
References	265
28. Pharmacology and Clinical Uses of <i>Ganoderma</i>	267
GENG-TAO LIU	
1. Introduction	267
2. Pharmacological Activities of the Alcohol-Water Soluble Fraction	267
3. Hepatoprotective Action of the Alcohol-Ether Soluble Fraction of <i>G. lucidum</i> Spores and <i>G. capense</i> Mycelium in Mice	271
4. Clinical Usage	271
5. Conclusion	272
References	273
29. Hepato-protective Triterpenoids from <i>Ganoderma tsugae</i> Murrill	275
C.H. SU, M.N. LAI AND M.H. CHAN	
1. Introduction	275
2. Materials and Methods	276
3. Results and Discussion	277
References	283
30. Immunomodulatory Activities of Mushroom Mycelial Extracts	285
W.K. LIU, V.E.C. OOI, T.B. NG AND S.T. CHANG	
1. Introduction	285
2. Materials and Methods	286

3. Results	286
4. Discussion	289
References	290
31. Advances in the Pharmacology of <i>Tremella</i> Polysaccharides	293
ZHI-BIN LIN	
1. Introduction	293
2. Antitumor Effect	293
3. Immunomodulating Effects	294
4. Protective Effect on Arrest of Bone Marrow	296
5. Effect of the Liver	297
6. Conclusions	298
References	298
32. Antitumor Components of <i>Collybia</i>	301
BYONG KAK KIM, SOOK HEE KIM AND EUNG CHIL CHOI	
1. Introduction	301
2. Methods	301
3. Results	302
References	303
Part V. FUTURE PROSPECTS FOR RESEARCH AND DEVELOPMENT	305
33. Promotion of Mushroom Production and Bioconversion of Wastes for Income Generation in Rural Areas: CDG-SEAPO's Biotechnology Training Project	307
GUENTER THARUN	
1. Introduction	307
2. Project Framework	309
3. Prospects and Constraints	313
References	318
34. Prospects and Problems in Commercialization of Small-scale Mushroom Production in South and Southeast Asia	321
J.D. FERCHAK AND J. CROUCHER	
1. Introduction	321
2. The Role of Development Assistance Organizations	322
3. Mushroom Project Activities in the Philippines	323

4. Assessments in Southeast Asia	326
5. Summary	328
References	328
35. Mushroom Cultivation: Environmental Problem to Environmental Benefit	331
DAN LEVANON	
1. Introduction	331
2. Recycling Organic Wastes via Mushroom Production	331
3. Unconventional Uses of Mushroom Technologies and Products	334
4. Conclusions	336
References	337
36. Extracellular Enzymes as Targets for Strain Improvement in <i>Agaricus bisporus</i>	339
D.A. WOOD	
1. Introduction	339
2. Laccase	340
3. Cellulase	341
4. Future Work	342
References	342
37. Mushrooms as a Source of Natural Flavor and Aroma Compounds	345
S.C. JONG AND J.M. BIRMINGHAM	
1. Introduction	345
2. Sources of Natural Flavor Compounds	345
3. Types of Aromatic Compounds	350
4. Mushrooms Known to Produce Aromatic Compounds	356
5. Culture Conditions for Production of Aromatic Compounds	363
6. Discussion	363
References	364
Index	367

List of Contributors

Number in parentheses indicate the pages on which the authors' contributions begin.

- N. ABHAYARATNA (193), Australian Quarantine and Inspection Service, Canberra, ACT, Australia.
S.O. AJLOUNI (177), Department of Food Science, The Pennsylvania State University, University Park, Pennsylvania, USA.
R.B. BEELMAN (177), Department of Food Science, The Pennsylvania State University, University Park, Pennsylvania, USA.
R.W. BENNETT (193), Food and Drug Administration, Washington, DC, USA.
M. S. BERGDOLL (209), Food Research Institute, University of Wisconsin, Madison, Wisconsin, USA.
J.M. BIRMINGHAM (345), American Type Culture Collection, 12301 Parklawn Drive, Rockville, Maryland 20852, USA.
PETER K. BUCHANAN (21), Manaaki Whenua - Landcare Research, Private Bag 92170, Auckland, New Zealand.
BRITT A. BUNYARD (49), Department of Plant Pathology, The Pennsylvania State University, University Park, Pennsylvania, U.S.A.
K.S. BURTON (171), Horticulture Research International, Littlehampton, West Sussex BN17 6LP, U.K.
J.A. BUSWELL (141), Department of Biology, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong.
Y.J. CAI (141), Department of Biology, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong.
K. CATHERWOOD (193), Health Protection Branch, Burnaby British Columbia, Canada.
M.H. CHAN (275), Institute for Chinese Medicine Research, Taipei Medical College, Taipei, China.
SHU-TING CHANG (3, 73, 141, 285), Department of Biology, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong.
WEI-LING CHENG (185), Department of Microbiology, China Import and Export Commodity Inspection Technology Institute, Gaobeidian North Road, Beijing 100025, China.
GORO CHIHARA (261), Biotechnology Research Centre, Teikyo University, Nogawa 907, Miyamae-ku, Kawasaki 213, Japan.
SIU-WAI CHIU (41), Department of Biology, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong.
EUNG CHIL CHOI (301), College of Pharmacy, Seoul National University, Seoul 151-742, Korea.
J. CROUCHER (321), Appropriate Technology International, Washington, D.C., USA.
J.D. FERCHAK (321), Appropriate Technology International, Washington, D.C., USA.
B. FRANCESCUTTI (93), AGRIFUNG, 31040 Musano di Trevignano, (TV), Italy.
H.S. GARCHA (227), Department of Microbiology, Punjab Agricultural University, Ludhiana, India.
E. GIORDANI (93), G.S. PLEUROTUS, 47020, Bagnile di Cesena, (FO), Italy.
AIDAH M. HANIFAH (55), Department of Life Science, University of Nottingham, Nottingham NG7 2RD, UK.

Y.J. HU (247), Department of Biology, Shanghai Teachers University, Shanghai 200234, China.
A. JANBEN (85), Research Institute for Mushroom Cultivation, Krefeld, Federal Republic of Germany.
JIAN-HUA JIA (55), Department of Life Science, University of Nottingham, Nottingham NG7 2RD, UK.
S.C. JONG (345), American Type Culture Collection, 12301 Parklawn Drive, Rockville, Maryland 20852, USA.
BYONG KAK KIM (301), College of Pharmacy, Seoul National University, Seoul 151-742, Korea.
SOOK HEE KIM (301), College of Pharmacy, Seoul National University, Seoul 151-742, Korea.
P.K. KHANNA (227), Department of Microbiology, Punjab Agricultural University, Ludhiana, India.
RALPH H. KURTZMAN, JR. (219), Western Regional Research Center, ARS, U. S. Department of Agriculture, 800 Buchanan Street, Albany, CA 94710, U.S.A.
J. LABORDE (93), INRA Mushroom Research Station, 33883 Villenave d'Ornon, France.
M.N. LAI (275), National Chiayii Institute of Agriculture, Chiayii, China.
G. LANZI (93), OK Press, Mushroom Information, San Giorgio di Piano, (BO), Italy.
J.I. LELLEY (85), Research Institute for Mushroom Cultivation, Krefeld, Federal Republic of Germany.
DAN LEVANON (331), Institute of Soils and Water, ARO, Bet Dagan, and MIGAL, Kiryat Shmona 10200, Israel.
CHAO-WEI LI (185), Department of Microbiology, China Import and Export Commodity Inspection Technology Institute, Gaobeidian North Road, Beijing 100025, China.
SHOU-SONG LI (185), Department of Microbiology, China Import and Export Commodity Inspection Technology Institute, Gaobeidian North Road, Beijing 100025, China.
X.Y. LI (247), Department of Biology, Shanghai Teachers University, Shanghai 200234, China.
M.L. LIAO (247), Department of Biology, Shanghai Teachers University, Shanghai 200234, China.
GENG-TAO LIU (267), Chinese Academy of Medical Sciences, Beijing 100050, China.
J.X. LIU (247), Department of Biology, Shanghai Teachers University, Shanghai 200234, China.
T.F. LIU (247), Department of Biology, Shanghai Teachers University, Shanghai 200234, China.
W.K. LIU (285), Department of Anatomy, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong.
ZHI-BIN LIN (293), Department of Pharmacology, Beijing Medical University, Beijing 100083, China.
L.J. LUKEY (193), Health Protection Branch, Burnaby, British Columbia, Canada.
X.C. LUO (129), Central China Agricultural University, Wuhan, China.
L. MA (163), Institute of Biotechnology, Hebei University, Baoding, China.
J.-L. MAU (177), Department of Food Science, The Pennsylvania State University, University Park, Pennsylvania, USA.
M.B. MIKLUS (177), Department of Food Science, The Pennsylvania State University, University Park, Pennsylvania, USA.
DAVID MOORE (33), Microbiology Research Group, School of Biological Sciences, The University, Manchester M13 9PT, U.K.
S. MURAKAMI (63), The Tottori Mycological Institute, Tottori, Japan.
N.G. NAIR (115), NSW Agriculture, Rydalmere, New South Wales, Australia.
T.B. NG (285), Department of Biochemistry, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong.

MICHAEL S. NICHOLSON (49), Department of Plant Pathology, The Pennsylvania State University, University Park, Pennsylvania, U.S.A.
V.E.C. OOI (285), Department of Biology, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong.
J. F. PEBERDY (55), Department of Life Science, University of Nottingham, Nottingham NG7 2RD, UK.
G. PRICE (115), Graham Price Pty Ltd., New South Wales, Australia.
DANIEL J. ROYSE (49), Department of Plant Pathology, The Pennsylvania State University, University Park, Pennsylvania, U.S.A.
HIROSHI SAKAGAMI (237), First Department of Biochemistry, School of Medicine, Showa University, 1-5-8 Hatanodai, Shinagawa-ku, Tokyo 142, Japan.
S.S. SIMONS (177), Department of Food Science, The Pennsylvania State University, University Park, Pennsylvania, USA.
G.L. SONI (227), Department of Microbiology, Punjab Agricultural University, Ludhiana, India.
C.H. SU (275), Institute for Chinese Medicine Research, Taipei Medical College, Taipei, China.
T. SULLIVAN (193), Food and Drug Administration, Washington, DC, USA.
K. SZUDYGA (123), Department of Edible Fungi, Institute of Vegetable Crops, Skierniewice, Poland.
MINORU TAKEDA (237), First Department of Biochemistry, School of Medicine, Showa University, 1-5-8 Hatanodai, Shinagawa-ku, Tokyo 142, Japan.
GUENTER THARUN (307), Carl Duisberg Gesellschaft-South East Program Office, Asian Institute of Technology, Bangkok, Thailand.
H.C. WANG (133), Fujian Research Institute of Light Industry, Fuzhou 350005, China.
Y. WANG (163), Institute of Biotechnology, Hebei University, Baoding, China.
Z.S. WANG (133), Fujian Research Institute of Light Industry, Fuzhou 350005, China.
D.A. WOOD (339), Horticulture Research International, Littlehampton, West Sussex BN17 6LP, U.K.
ZHONG-LIANG WU (185), Department of Microbiology, China Import and Export Commodity Inspection Technology Institute, Gaobeidian North Road, Beijing 100025, China.
G.M. XU (247), Department of Biology, Shanghai Teachers University, Shanghai 200234, China.
G.L. YANG (163), Institute of Biotechnology, Hebei University, Baoding, China.
Q.Y. YANG (247), Department of Biology, Shanghai Teachers University, Shanghai 200234, China.
S.X. YANG (247), Department of Biology, Shanghai Teachers University, Shanghai 200234, China.
Y.W. YANG (163), Institute of Biotechnology, Hebei University, Baoding, China.
FRANTISEK ZADRAZIL (151), Institut für Bodenbiologie, Bundesforschungsanstalt für Landwirtschaft, Bundesallee 50, 3300 Braunschweig, FRG.
ZHONG-CHANG ZHANG (185), Department of Microbiology, China Import and Export Commodity Inspection Technology Institute, Gaobeidian North Road, Beijing 100025, China.