Handbook of herbs and spices

Edited by

K. V. Peter

CRC Press
Boca Raton Boston New York Washington, DC

WOODHEAD PUBLISHING LIMITED
Cambridge England

Published by Woodhead Publishing Limited
Abington Hall, Abington
Cambridge CB1 6AH
England
www.woodhead-publishing.com

Published in North and South America by CRC Press LLC
2000 Corporate Blvd, NW
Boca Raton FL 33431
USA

First published 2001, Woodhead Publishing Limited and CRC Press LLC

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library.

Library of Congress Cataloging-in-Publication Data
A catalog record for this book is available from the Library of Congress.

Woodhead Publishing Limited ISBN 1 85573 562 8
CRC Press ISBN-0 8493-1217-5
CRC Press order number: WP1217

Cover design by The ColourStudio
Project managed by Macfarlane Production Services, Markyate, Hertfordshire (email: macfarl@aol.com)
Typeset by MHL Typesetting Limited, Coventry, Warwickshire
Printed by TJ International, Padstow, Cornwall, England

Related titles on food science and technology from Woodhead Publishing:

Antioxidants in food (ISBN: 1 85573 463 X)

Antioxidants are a major ingredient in food processing, both in controlling oxidation and in influencing other aspects of food quality as well as providing potential health benefits. This collection reviews antioxidant use, particularly the increasing role of natural antioxidants in food processing

Functional foods (ISBN: 1 85573 503 2)

Functional foods are widely predicted to become one of the biggest dietary trends of the next 25 years. The editors of this book have gathered together leading experts to provide the food industry with a single authoritative resource. This book first defines and classifies the field of functional foods, paying particular attention to the legislative aspects in both the EU and the USA. It then summarises the key work on functional foods and the prevention of disease. Finally, there is a series of chapters on the issues in developing functional foods in practice.

New ingredients in food processing (ISBN: 1 85573 443 5)

The food industry is now seeing a rapidly expanding primary processing industry manufacturing tailor-made ingredients (or intermediate food products) for the secondary sector. This major new text offers a comprehensive guide to the range of IFPs available, their key benefits (greater flexibility, functionality and more consistent quality) and the ways in which their manufacture can be tailored to the requirements of the food industry.

Details of these books and a complete list of Woodhead's food science, technology and nutrition titles can be obtained by:

- visiting our web site at www.woodhead-publishing.com
- contacting Customer Services (e-mail: sales@woodhead-publishing.com; fax: +44 (0) 1223 893694; tel.: +44 (0) 1223 891358 ext.30; address: Woodhead Publishing Limited, Abington Hall, Abington, Cambridge CB1 6AH, England)

If you would like to receive information on forthcoming titles in this area, please send your address details to: Francis Dodds (address, tel. and fax as above; e-mail: francisd@woodhead-publishing.com). Please confirm which subject areas you are interested in.

Contributors

Chapter 1

Professor K. V. Peter
Director of Research
Kerala Agricultural University
P.O. K.A.U. – 680 656
Trichur
Kerala
India

Tel: +91 487 371302
Fax: +91 487 370019
E-mail: kvptr@yahoo.com;
kauhqr@ren.nic.in

Chapter 2

Ms Maria Clay and Martin Muggeridge,
Lion Foods Seasoning and Spice Association
6 Catherine Street
London WC2B 5JJ
England

Tel: +44 (0)208 836 2460
Fax: +44 (0)208 836 0580
E-mail: mclay@fdf.org.uk

Chapter 3

Dr Rehka S. Singhal, Professor Pushpa R. Kulkarni and Dr V. Rege
University Department of Chemical Technology (UDCT)
University of Mumbai
Nathalal Parikh Marg
Matunga, Mumbai 400 019
India

Tel: +91 22 414 5616
Fax: +91 22 414 5614
E-mail: rekha@foodbio.udct.ernet.in

Chapter 4

Dr C. K. George
Peermade Development Society
P. B. No. 11, Peermade-685 531
Indukki District
Kerala
India

Tel: +91 486 332497, 332496, 332197
Fax: +91 486 332096
E-mail: pedes@satyam.net.in
pedes@md2.vsnl.net.in

Chapter 5

Professor Dr Mensure Özgüven
Department of Field Crops
Faculty of Agriculture
University of Cukurova
Adana - 01330
Turkey

Fax: +90 322 338 63 81
E-mail: mensur@mail.cu.edu.tr

Chapter 6

Dr Sushil Kumar
Director
Central Institute of Medicinal and Aromatic Plants
Lucknow 226015
India

Fax: +91 522 342666
E-mail: cimap@satyam.net.in

Chapter 7

Dr P. N. Ravindran and Dr Johny A. Kallupurackal
Indian Institute of Spices Research
PB No 1701
Marikunnu PO
Calicut-673012
Kerala
India

Fax: +91 495 370294
E-mail: iisrclt@md3.vsnl.net.in

Chapter 8

Dr T. G. Berke and Dr S. C. Shieh
Associate Scientist
Asian Vegetable Research and Development Center
PO Box 42 Shanua
Tainan 741
Taiwan

Fax: +886 6 583 0009
E-mail: (terry@neta.avrdc.org.tw), jin@netra.avrdc.org.tw

Chapter 9

Dr V. S. Korikanthimath
Cardamom Research Centre
Indian Institute of Spices Research
Appangala
Madikeri- 571 201 Kodagu Dt
Karnataka
India

Fax: +91 0827 228591
E-mail: iisrclt@md3.vsml.net.in

Chapter 10

Dr K. J. Madhusoodanan and Dr Y Saideswara Rao
Indian Cardamom Research Institute
Spices Board
Myladumpara 685 553
Kerala
India

Fax: +91 0484 331429
E-mail: mail@indianspices.com
spicesboard@vsnl.com

Chapter 11

Dr J. Thomas and Dr P. P. Duethi
Kerala Agricultural University
Aromatic and Medicinal Plants Resrach Station
PO Asamannur
Ernakulam
Kerala 683 549
India

E-mail: amprs@ker.nic.in

Chapter 12

Dr N. Nurdjannah and Dr Nurliani Bermawie
Research Institute for Spice and Medicinal Crops
Jalan Tentara Pelajar
Indonesia

Fax: +62 251 327010
E-mail: criec@indo.net.id

Chapter 13

Professor Gholamreza Amin
Faculty of Pharmacy
Tehran University of Medical Sciences
PO Box 14155-6451
Tehran
Iran

E-mail: gh_amin@yahoo.com

Chapter 14

Dr J. Salikutty and Professor K. V. Peter
Department of Olericulture
Kerala Agricultural University
Vellaikkara
Thrissur 680656
Kerala
India

Fax: +91 487 370019
E-mail: kauhqr@ren.nic.in

Chapter 15

Dr Rajendra Gupta
Project Coordinator
Zandu Pharmaceuticals
B-1/46
Paschim Bihar
New Delhi 110063
India

Chapter 16

Dr U. B. Pandey
National Horticultural Research and Development Foundation
Post Box 61
Kanda Batata Bhavan 2954-E
New Bombay Agra Road
Nashik 422001
(MS) India

Fax: +91 0253 596606
E-mail: nhrdf@bom6.vsnl.net.in

Chapter 17

Dr P. A. Valsala
Department of Plantation Crops and Spices
College of Horticulture
Kerala Agricultural University
Vellanikkara PO
Thrissur
Kerala
India

Fax: +91 487 370019
E-mail: pavalsala@123india.com

Chapter 18

Dr V. K. Raju and Dr M. Reni
Department of Processing Technology
College of Horticulture
P.O. Kerala Agricultural University
Vellanikkara
Thrissur 680 656
Kerala
India

Fax: +91 487 370019
E-mail: rajuvk@md3.vsnl.net.in

Chapter 19

Dr S. N. Potty and Dr V. Krishna Kumar
Indian Cardamom Research Institute
PO Mailadumpara
Idukki
Kerala
India

E-mail: mylaicri@eth.net

Chapter 20

Mr B. Krishnamoorthy and Dr J. Rema
India Institute of Spices Research
Calicut 673 012
Kerala
India

Fax: +91 495 370294
E-mail: iisrclt@md3.vsnl.net.in

Chapter 21

Dr K. E. Lawande
National Research Centre for Onion and Garlic
Rajgurunager- 410 505
Dist Pune
(MS) India

Fax: +91 2135 24056
E-mail: nrcogrpn@mah.nic.in

Chapter 22

Dr P. Pushpangadan and Dr S. P. Singh
National Botanical Research Institute
Lucknow-226001
India

E-mail: pushpangadan@satyam.net.in

Chapter 23

Professor Nedyalka V. Yanishlieva-Maslarova
Institute of Organic Chemistry
Bulgarion Academy of Sciences
Kv Geo Milev, Acad G. Bonchev Str., Blok 9
BG-1113 Sofia
Bulgaria

Tel: +359 2 7134 178
Fax: +359 2 700225
E-mail: nelly@orgchem.bas.bg

Chapter 24

Professor Arturo Velasco-Negueruela
Departmento De Biologia
Facultad de Biologia
Universidad Complutense
28040 Madrid
Spain

Tel/Fax: +34 91 394 44 14/50 34
E-mail: bioveg@eucmax.sim.ucm.es

Chapter 25

Dr Y. Saideswara Rao and
K. Mary Mathew
Indian Cardamom Research Institute
Spices Board
Myladumpara 685 553
Kerala
India

Fax: +91 0484 331429
E-mail: mail@indianspices.com
spicesboard@vsnl.com

Chapter 26

Dr B. Sasikumar
Indian Institute of Spices Research
PO Marikunnu
Calicut 673012
Kerala
India

Fax: +91 495 370294
E-mail: iisrclt@md3.vsnl.net.in

Index

Contents

Handbook of herbs and spices

Volume 2

Edited by
K. V. Peter

CRC Press
Boca Raton Boston New York Washington, DC

WOODHEAD PUBLISHING LIMITED
Cambridge England

Published by Woodhead Publishing Limited, Abington Hall, Abington
Cambridge CB1 6AH, England
www.woodhead-publishing.com

Published in North America by CRC Press LLC, 2000 Corporate Blvd, NW
Boca Raton FL 33431, USA

First published 2004, Woodhead Publishing Ltd and CRC Press LLC

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library.

Library of Congress Cataloging in Publication Data
A catalog record for this book is available from the Library of Congress.

Woodhead Publishing ISBN 1 85573 721 3 (book) 1 85573 835 X (e-book)
CRC Press ISBN 0-8493-2535-8
CRC Press order number: WP2535

The publisher's policy is to use permanent paper from mills that operate a sustainable forestry policy, and which have been manufactured from pulp which is processed using acid-free and elementary chlorine-free practices. Furthermore, the publisher ensures that the text paper and cover board used have met acceptable environmental accreditation standards.

Typeset by Ann Buchan (Typesetters), Middx, England
Printed by TJ International, Padstow, Cornwall, England

Contributors

(* = main point of contact)

Chapter 1

Professor K. V. Peter*
Kerala Agricultural University
KAU – PO, Vellanikkara
Thrissur, Kerala State
India – 680656

Tel: 0487 2370034
Fax: 0487 2370019
E-mail: vckau@sancharnet.in
kvptr@yahoo.com

Dr K. Nirmal Babu
Indian Institute of Spices Research
Calicut – 673 012
India

Tel: 0495 2731410
Fax: 0495 2730294
E-mail: nirmalbabu30@hotmail.com

Chapter 2

M. R. Shylaja and Professor K. V. Peter*
Kerala Agricultural University
P O KAU 680656, Vellanikkara
Thrissur, Kerala State
India – 680656

Tel: 0487 2370034
Fax: 0487 2370019
E-mail: vckau@sancharnet.in
kvptr@yahoo.com
mrshyla@rediffmail.com

Chapter 3

Dr C. C. Tassou
National Agricultural Research Foundation
Institute of Technology of Agricultural Products
S Venizelou 1
Lycovrisi 14123
Greece

Tel: +30 210 2845940
Fax: +30 210 2840740
E-mail: microlab.itap@nagref.gr

Professor G.-J. E. Nychas* and Dr P. N. Skandamis
Agricultural University of Athens
Department of Food Science and Technology
Iera Odos 75
Athens 11855
Greece

Tel/Fax: +30 10 529 4693
E-mail: gjn@aua.gr

Chapter 4

Dr R. Rodenburg
TNO Pharma
Utrechtseweg 48
3704HE Zeist
The Netherlands

Tel: +31 30 6944844
Fax: +31 30 6944845
E-mail: pharma-office@pharma.tno.nl

Chapter 5

P. N. Ravindran* and G. S. Pillai
Centre for Medicinal Plants Research
Arya Vaidya Sala
Kottakkal – 676 503
Kerala
India

Tel: 0483 2743430
Fax: 0483 2742572/2742210
E-mail: avscmpr@sify.com
avscmpr@yahoo.co.in

Dr K. Nirmal Babu
Indian Institute of Spices Research
Calicut – 676 012
India

Tel: 0495 2731410
Fax: 0495 2730294
E-mail: nirmalbabu30@hotmail.com

Chapter 6

Dr S. K. Malhotra* and Dr O. P. Vijay
National Research Centre on Seed Spices
Ajmer – 305 206
Rajasthan
India

Tel: +91 145 2680955
Fax: +91 145 2443238
E-mail: malhotraskraj@yahoo.com

Chapter 7

Mr B. Krishnamoorthy* and Dr J. Rema
Indian Institute of Spices Research
Calicut 673 012
Kerala
India

E-mail: bkrishnamoorthy@rediffmail.com
remachaithram@yahoo.co.in

Chapter 8

Dr A. A. Farooqi* and K. N. Srinivasappa
Division of Horticulture
University of Agricultural Sciences
GKVK
Bangalore
India

E-mail: azharfarooqi@sify.com

Chapter 9

Dr M. M. Sharma* and Dr R. K. Sharma
Rajasthan Agricultural University
Bikaner
India

E-mail: mmohanrau@yahoo.com

Chapter 10

Dr M. T. Lis-Balchin
School of Applied Science
South Bank University
103 Borough Road
London SE1 0AA

E-mail: lisbalmt@lsbu.ac.uk

Chapter 11

Dr M. T. Lis-Balchin
School of Applied Science
South Bank University
103 Borough Road
London SE1 0AA

E-mail: lisbalmt@lsbu.ac.uk

Chapter 12

Dr J. Thomas*, K. M. Kuruvilla and T. K. Hrideek
ICRI Spices Board
Kailasanadu PO
Kerala, India – 685 553

E-mail: jtkotmala@hotmail.com

Chapter 13

Dr S. K. Malhotra
National Research Centre on Seed Spices
Ajmer – 305 206
Rajasthan
India

Tel: +91 145 2680955
Fax: +91 145 2443238
E-mail: malhotraskraj@yahoo.com

Chapter 14

Professor S. Kintzios
Laboratory of Plant Physiology
Agricultural University of Athens
Iera Odos 75
11855 Athens
Greece

Tel: +3210 5294292
Fax: +3210 5294286
E-mail: skin@aua.gr

Chapter 15

Dr D. J. Charles
Frontier Natural Products Co-op
3021 78th Street
Norway, IA
52318
USA

E-mail: denys.charles@frontiercoop.com

Chapter 16

Dr B. Sasikumar
Indian Institute of Spices Research
Marikunnu (PO)
Calicut – 673 012
Kerala
India

Tel: 91 495 2731410
Fax: 91 495 2730294
Email: bhaskaransasikumar@yahoo.com

Chapter 17

Dr D. M. Hegde
Directorate of Oilseeds Research
Rajendranagar
Hyderabad – 500 030
Andhra Pradesh
India
Tel: +91 040 24015222
Fax: +91 040 24017969

E-mail: dmhegde@rediffmail.com

Chapter 18

C.K. George
Peermade Development Society
Post Box 11
Peermade – 685531
Idukki Dist.
Kerala
India

E-mail: ckgeorge@vsnl.com

Chapter 19

Professor E. Stahl-Biskup*
University of Hamburg
Institute of Pharmacy
Department of Pharmaceutical Biology and Microbiology
Bundesstrasse 45
D-20146 Hamburg
Germany

Tel: +49 (0)40 42838 3896
Fax: +49 (0)40 42838 3895
E-mail: elisabeth.stahl-biskup
@uni-hamburg.de

Professor R. P. Venskutonis
Head of Department of Food Technology
Radvilenu pl. 19
Kaunas
LT – 3028
Lithuania

Tel: +370 37 456426
Fax: +370 37 456647
E-mail: rimas.venskutonis@ktu.lt

Chapter 20

Dr C. C. de Guzman
Department of Horticulture
College of Agriculture
University of the Philippines Los Baños
Los Baños
Laguna 4031
Philippines

Tel: (63-49) 536 2448
Fax: (63-49) 536 2478
E-mail: tanchodg@lb.msc.net.ph

Index

Contents

Handbook of herbs and spices

Volume 3

Edited by
K. V. Peter

CRC Press
Boca Raton Boston New York Washington, DC

WOODHEAD PUBLISHING LIMITED
Cambridge, England

Published by Woodhead Publishing Limited, Abington Hall, Abington
Cambridge CB1 6AH, England
www.woodheadpublishing.com

Published in North America by CRC Press LLC, 6000 Broken Sound Parkway, NW,
Suite 300, Boca Raton, FL 33487, USA

First published 2006, Woodhead Publishing Limited and CRC Press LLC

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library.

Library of Congress Cataloging in Publication Data
A catalog record for this book is available from the Library of Congress.

Woodhead Publishing ISBN-13: 978-1-84569-017-5 (book)
Woodhead Publishing ISBN-10: 1-84569-017-6 (book)
Woodhead Publishing ISBN-13: 978-1-84569-171-4 (e-book)
Woodhead Publishing ISBN-10: 1-84569-171-7 (e-book)
CRC Press ISBN-13: 978-0-8493-9155-2
CRC Press ISBN-10: 0-8493-9155-5
CRC Press order number: WP9155

The publishers' policy is to use permanent paper from mills that operate a sustainable forestry policy, and which has been manufactured from pulp which is processed using acid-free and elementary chlorine-free practices. Furthermore, the publishers ensure that the text paper and cover board used have met acceptable environmental accreditation standards.

Project managed by Macfarlane Production Services, Dunstable, Bedfordshire
(e-mail: macfarl@aol.com)

Typeset by Replika Press Pvt Ltd, India
Printed by T J International Limited, Padstow, Cornwall, England

Contributor contact details

(* = main point of contact)

Editor
Professor K. V. Peter
Kerala Agricultural University
KAU-PO
Vellanikkara, Thrissur – 680656
Kerala State
India

E-mail: kvptr@yahoo.com

Chapter 1
Dr D. Heperkan
Department of Food Engineering
Istanbul Technical University
34469 Maslak
Istanbul
Turkey

E-mail: heperkan@itu.edu.tr

Chapter 2
Dr K. J. Venugopal
G – 339
'Aparna'
Panampilly Nagar
Kochi 682 036
Ernakulam District
Kerala
India

E-mail: venukj@yahoo.com

Chapter 3
Dr A. Sharma
Food Technology Division
Bhabha Atomic Research Centre
Mumbai – 400 085
India

E-mail: ksarun@apsara.barc.ernet.in

Chapters 4 and 12
Dr C. K. George
7520 Weymouth Hill Road
Clifton, VA 20124
USA

E-mail: ckgeorge@gmail.com

Chapter 5
Ms K. King
Gourmet Garden
PO Box 128
Palmwoods
Queensland
Australia 4555

E-mail: Kerri.King@gourmetgarden.com

Chapter 6
Ms C. Kehler
Canadian Herb, Spice and Natural Health Product Coalition
Saskstchewan Herb and Spice Association
Box 60 Belle Plaine
Saskatchewan S0G 0G0
Canada

E-mail: shsa@imagewireless.ca

Jan Schooley
Box 587 Simcoe
Ontario
Canada N37 4NS

E-mail: jan.schooley@omafra.gov.on.ca

Chapter 7
Dr T. S. C. Li
Agriculture and Agri-Food Canada
PARC Summerland
4200 Hwy 97
Box 5000
Summerland BC
Canada V0H 1Z0

E-mail: lit@agr.gc.ca

Chapter 8
Dr H. A. Collin
11 Johnsons Close
Westminister Park
Chester CH4 7RB
UK

E-mail: H.A.Collin@liverpool.ac.uk

Chapter 9
Dr Satyabrata Maiti* and Dr K. A. Geetha
National Research Centre for Medicinal and Aromatic Plants
Boriavi 387 310
Anand
Gujarat
India

E-mail: satyabratamaiti@hotmail.com
geethaka99@yahoo.com

Chapter 10
Dr C. C. Tassou
National Agricultural Research Foundation
Institute of Technology of Agricultural Products
S Venizelou 1
Lycovrissi 14123
Greece

E-mail: microlab.itap@nagref.gr

Chapter 11
Dr T. J. Zachariah* and Dr N. K. Leela
Indian Institute of Spices Research
Marikunnu (PO)
Calicut-673 012
Kerala
India

E-mail: john@iisr.org

Chapter 13
Dr Gabriel O. Sozzi*
Cátedra de Fruticultura
Facultad de Agronomía
Universidad de Buenos Aires and CONICET
Avda. San Martín 4453
C 1417 DSE – Buenos Aires
Argentina

E-mail: gsozzi@agro.uba.ar

Dr Ariel R. Vicente
Centro de Investigación y Desarrollo en Criotecnología de Alimentos
CONICET–UNLP
47 and 116
B 1900 AJJ – La Plata
Argentina

Chapter 14

Dr K. Nirmal Babu* and
Dr M. Divakaran
Indian Institute of Spices Research
Marikunnu (PO)
Calicut – 673 012
Kerala
India

E-mail: nirmalbabu30@hotmail.com

Dr K. V. Tushar and Dr P. N. Ravindran
Centre for Medicinal Plants Research
PS Warriers Arya Vaidya Sala
Kottakkal
Kerala
India

E-mail: pnravi2003@yahoo.co.in

Chapters 15 and 18

Dr S. K. Malhotra
National Research Centre for Seed Spices
Ajmer – 305 206
Rajasthan
India

E-mail: malhotraskraj@yahoo.com

Chapter 16

Dr S. Kumar*, Dr R. Kumar and
Dr J. Singh
Indian Institute of Vegetable Research
Post Box 5002
Varanasi
India

E-mail: sanjeetk1@sify.com

Chapter 17

Dr A. A. Farooqi* and K. N. Srinivasappa
Division of Horticulture
University of Agricultural Sciences
GKVK
Bangalore
India

E-mail: aa.farooqi@rediffmail.com

Chapter 19

Dr H. Chen
Beijing Vegetable Research Centre (BVRC)
Banjing West Suburb
P. O. Box 2443
Beijing 100089
China

E-mail: rlzong@yahoo.com

Chapter 20

Dr P. N. Ravindran* and Dr G. S. Pillai
Centre for Medicinal Plants Research
Arya Vaidya Sala
Kottakkal – 676 503
Kerala
India

E-mail: pnravi2003@yahoo.co.in
pn-rnair@hotmail.com

Chapter 21

Dr P. N. Ravindran* and
Dr I. Balachandran
Centre for Medicinal Plants Research
Arya Vaidya Sala
Kottakkal – 676 503
Kerala
India

E-mail: pnravi2003@yahoo.co.in
pn-rnair@hotmail.com

Chapter 22
Dr K. R. M. Swamy* and
Dr R. Veere Gowda
Indian Institute of Horticultural Research
Hessaraghatta Lake Post
Bangalore 560 089
India

E-mail: krmswamy@yahoo.co.in

Chapter 23
Dr H. Turhan
Department of Field Crops
Faculty of Agriculture
Canakkale Onsekiz Mart University
Terzioglu Campus 17020
Canakkale
Turkey

E-mail: hturhan@comu.edu.tr

Chapter 24
Dr Baby. P. Skaria*, Dr P. P. Joy,
Dr S. Mathew and Dr G. Mathew
Aromatic and Medicinal Plants Research Station
Odakkali
Asamannor PO
Ernakalam-683 549
India

E-mail: amprs@satyam.net.in

Chapter 25
Dr K. Nirmal Babu* and
Dr M. Divakaran
Indian Institute of Spices Research
Calicut – 673 012
Kerala
India

E-mail: nirmalbabu30@hotmail.com

Dr P. N. Ravindran and
Professor K. V. Peter
Centre for Medicinal Plants Research
Arya Vaidya Sala
Kottakkal – 676 503
Kerala
India

E-mail: avscmpr@sify.com
avscmpr@yahoo.co.in

Chapter 26
Dr M. H. Mirjalili*
Medicinal Plants and Drug Research Institute
Shahid Beheshti University
Tehran
Iran

E-mail: M-Mirjalili@cc.sbu.ac.ir

Dr J. Javanmardi
Department of Horticulture
Faculty of Agriculture
Shiraz University
Shiraz
Iran

E-mail: jmljvn@yahoo.com

Chapter 27
Dr S. Wongpornchai
Faculty of Science
Chiang Mai University
239 Huay Kaew Road
Chiang Mai 50200
Thailand

E-mail: scismhth@chiangmai.ac.th

Chapter 28
Dr P. Pushpangadan*
Amity Institute for Herbal and Biotech Products Development
c/o Ranjeev Gandhi Center for Biotechnology
Thiruvananthapuram
India

E-mail: palpuprakulam@yahoo.co.in

Dr S. K. Tewari
National Botanical Research Institute
Lucknow – 226 001
India

Chapter 29
Dr P. N. Ravindran*
Centre for Medicinal Plants Research
Arya Vaidya Sala
Kottakkal – 676 503
Kerala
India

E-mail: avscmpr@sify.com
avscmpr@yahoo.co.in

Dr M. Shylaja
Providence Women's College
Calicut – 673 009
Kerala
India

Chapter 30
Dr U. B. Pandey
Jain Irrigation Systems Limited
Agri Park, Jain Hill
Shirsoli Road
Jalgaon 425 001
India

E-mail: agripark@jains.com

Chapter 31
Dr N. K. Patra and Dr B. Kumar
Central Institute of Medicinal and Aromatic Plants
PMVD Division
CIMAP
P.O. CIMAP
Lucknow – 226 015
(UP) India

E-mail: dr_nkpatra@yahoo.co.in
birenk67@yahoo.co.in

Introduction

Herbs and spices play a pivotal role in the day-to-day life of mankind as important flavouring agents in foods, beverages and pharmaceuticals and also as ingredients in perfumes and cosmetics. The manufacturers of foods, beverages, cosmetics and pharmaceuticals are responding to the growing wave of consumer resistance and legislative limitations set for products containing chemical additives. Spices as sources of natural colours and flavours present welcome opportunities in the international market. The nutritional, antioxidant, antimicrobial and medicinal properties of spices also have widespread applications.

I.1 Production of quality spices

Production of quality clean spices without any pesticide/chemical residues is important in this era of free international trade resulting from globalisation. Organic spices which fetch 20 to 50% higher prices than spices from conventional farms are devoid of pesticides and chemical residues and are superior in quality. Adoption of good agricultural practices helps to reduce the above contaminants. Quality assurance systems such as HACCP is of great relevance in the production of quality spices. Decontamination techniques and proper packaging and storage techniques play a major role in maintaining quality of spices.

I.1.1 Rational uses of pesticides and controlling the pesticide/chemicals residues in herbs and spices

All over the world, people are becoming more and more conscious of health problems due to consumption of foods contaminated with pesticide residues. It is estimated that a large number of people suffer from pesticide poisoning and suffer every year due to the toxic effects of chemicals. Promotion of a farming technique adopting ecologically sound plant protection measures, organic recycling and bio-waste management would go a long way in bringing back the health of soil and reducing the pesticide residues of farm produce. The role played by various beneficial microorganisms including mycorrhizae, biocontrol agents and plant-growth-promoting rhizobacteria are enormous in enhancing crop growth and disease control without leaving any chemical residues on plants. The effective bioagents for the control of major diseases of spice crops are listed in Table I.1.

Table I.1 Effective bio agents for the control of major diseases in spice crops

Crops	Major diseases	Causal organisms	Bio control agents
Cardamom (small)	Azhukal	*Phytophthora meadii, P. nicotianae* var. *nicotianae*	*Trichoderma viride* *T. harzianum* *Laetisaria arvalis*
	Rhizome rot	*Rhizoctonia solani, Pythium vexans*	*Gliocladium virens* *Arbiscular Mycorhizal Fungi (AMF)*
	Seed rot	*Fusarium oxysporum*	*Trichoderma* sp.
	Seedling rot	*R. solani, P. vexans*	*Pseudomonas fluorescens*
	Root rot	*F. oxysporum*	*Bacillus subtilis*
Black pepper	Foot rot (quick wilt)	*Phytophthora capsici*	*AMF* *T. viride, T. harzianum, Gliocladium virens* *Paecilomyces lilacinus*
	Slow decline (slow wilt)	*Rodophilus similies, Meloidogyne incognita*	*G. virens, T. viride* *T. harzianum, AMF* *Verticillum, Chlamydosporium* sp. *Pasteuria penetrans*
Vanilla	Root rot	*Fusarium oxysporum, Sclerotium rolfsi*	*T. viride, T. harzianum*
	Stem rot, stem blight, beans rot, beans yellowing and rotting shoot tip rot	*P. meadii, F. oxysporum* *Sclerotium rolfsii* *F. oxysporum, Colletotrichum gloeosporioides*	*B. subtilis* *P. fluorescens* *T. viride* *T. harzianum* *P. fluorescens*
Ginger	Soft rot (rhizome rot)	*Pythium aphanidermatum, P. myriotylum,*	*T. viride* *T. harzianum*
	Ginger yellows	*Fusarium* sp.	*Trichoderma* sp.
Turmeric	Rhizome rot Storage rots	*Rhizoctonia solani, Sclerotium rolfsii*	*Trichoderma* sp.
Chillies, Paprikas	Damping off in seedlings	*Pythium* sp., *Phytophthora* sp.	*T. viride* *T. harzianum* *P. fluorescens*
	Anthracnose (fruit rot)	*Colletotrichum lindemuthianum*	*B. subtilis* *P. fluorescens* *B. subtilis* *Trichoderma* sp.
Thyme	Wilt disease	*F. oxysporum*	*T. viride*
	Leaf rot	*F. oxysporum*	*T. harzianum*
Rosemary	Thread blight	*Rhizoctonia solani*	*T. harzianum*
Sage	Wilt	*R. solani*	*T. harzianum*
Mint	Wilt	*F. oxysporum*	*T. harzianum*
Horse-radish	Leaf blight	*Colletotrichum* sp.	*T. harzianum*
	Root rot, wilt	*Verticillium* sp.	*T. harzianum*
Burmese-coriander	Wilt	*Fusarium* sp.	*T. harzianum*
Marjoram	Leaf blight	*Colletotrichum* sp.	*T. harzianum*
	Leaf spot	*Phoma* sp.	*T. harzianum*
Oregano	Leaf spot	*Curvularia lunata*	*T. harzianum*

Guidelines for production of organic spices are developed for various producing countries. The Spices Board of India (2001) published the guidelines for production of organic spices in India. The nutrient composition of selected organic cakes and recommended quantity of organic manure for various spice crops are presented in Table I.2.

I.1.2 Radiation processing to decontaminate spices

Radiation processing offers good scope for increasing shelf life, enhancing quality and microbial safety without changing the natural flavour attributes of spices. This technique is widely practised in North America and Europe to decontaminate imported

Table I.2 (a) Nutrient composition of selected organic cakes and (b) recommended quantity of organic manure for various spice crops

(a)

Oil cakes	Nutrient contents (%)		
	Nitrogen	Phosphorus	Potash
Edible cakes			
Coconut cake	3.0	1.9	1.8
Niger cake	4.7	1.8	1.2
Sesamum cake	6.2	2.0	1.2
Sunflower cake	7.9	2.2	1.9
Groundnut cake	7.3	1.5	1.3
Non-edible cake			
Cotton seed cake (with shells)	6.4	2.9	2.2
Mahua cake	2.51	0.80	1.85
Neem cake	5.22	1.08	1.48

(b)

Spice crops	Organic manure	Quantity
Black pepper	Farmyard manure	4–10 kg/plant
Small cardamom	Neem cake/FYM/Vermicompost/Poultry manure	4–5 kg/plant
Large cardamom	Cattle manures/organic cakes	2 kg/plant
Vanilla	Farmyard manure/Vermicompost	4–5 kg/plant
Chilli	Farmyard manure/	4–5 t/ha
	Sheep manure/	3–5 q/ha
	Neem cake	3–4 q/ha
Ginger	Farmyard manure/	5–6 t/ha
	Neem cake	2 t/ha
Turmeric	Farmyard manure/	5–6 t/ha
	Neem cake	2 t/ha
Fennel	Farmyard manure	10–12 t/ha
Coriander	Farmyard manure	4 t/ha
Cumin	Farmyard manure	4–5 t/ha
Fenugreek	Farmyard manure	4–5 t/ha
Celery	Farmyard manure	10–12 t/ha
Clove	Farmyard manure	15–40 kg/plant
Nutmeg	Farmyard manure	15–40 kg/plant

Source: Spices Board of India (2001).

spices. The various producing countries also started installing facilities for radiation processing of spices. Radiation sterilisation along with good agricultural and manufacturing practices help to produce clean, high quality spices free from pesticide and chemical residues. Being a cold process, it does not affect the delicate aroma and flavour compounds in spices. The risk of post-treatment contamination can be eliminated by subjecting the pre-packed spices to irradiation. Table I.3 gives the list of countries that have approved irradiation processing of food products and spices items permitted for irradiation under the Indian Prevention of Food Adulteration Act (PFA) rules.

Low doses of irradiation (< 1 K.Gy) help to inhibit sprouting in onion, garlic, ginger, etc. A medium dose application (1–10 K.Gy) eliminates spoilage microbes and food pathogens and high dose application (>10 K.Gy) sterilises food for special requirements and for shelf-stable foods without refrigeration.

I.1.3 Packaging in spices for maintenance of quality

Spice products are hygroscopic in nature and being highly sensitive to moisture,

Table I.3 (a) Countries which have approved radiation processing of food products and (b) spice items permitted for irradiation under Indian Prevention of Food Adulteration Act (PFA) rules

(a)

S. no.	Country	S. no.	Country	S. no.	Country
1	Argentina	19	Ghana	37	Philippines
2	Australia	20	Greece	38	Poland
3	Austria	21	Hungary	39	Portugal
4	Bangladesh	22	India	40	Russian Federation
5	Belgium	23	Indonesia	41	South Africa
6	Brazil	24	Iran	42	Spain
7	Canada	25	Ireland	43	Sweden
8	Chile	26	Israel	44	Syria
9	China	27	Italy	45	Thailand
10	Costa Rica	28	Japan	46	Turkey
11	Croatia	29	Republic of Korea	47	Ukraine
12	Cuba	30	Libya	48	UK
13	Czech Republic	31	Luxemburg	49	Uruguay
14	Denmark	32	Mexico	50	USA
15	Egypt	33	Netherlands	51	Vietnam
16	Finland	34	New Zealand	52	Yugoslavia
17	France	35	Norway		
18	Germany	36	Pakistan		

(b)

Name of spice	Dose of irradiation		Purpose
	Minimum	Maximum	
Onion	0.03	0.09	Sprout inhibition
Shallots (small onion)	0.03	0.15	Sprout inhibition
Garlic	0.03	0.15	Sprout inhibition
Ginger	0.03	0.15	Sprout inhibition
Spices	6.0	14.0	Microbial decontamination

Source: Sharma *et al*. (2003).

absorption of moisture may result in caking, discolouration, hydrolytic rancidity, mould growth and insect infestation. As spices contain volatile aromatic principles, loss of these principles and the absorption of foreign odours as a result of inefficient packaging may pose serious problems. In addition, heat and light accelerate deterioration of aroma and flavour components.

Spices containing natural colouring pigments need protection from light (capsicum, cardamom, turmeric and saffron). Spice powders like onion and garlic contain highly volatile sulphur compounds and need rigorous protection from loss/absorption of flavour. The essential oil components naturally present in most of the spices are subject to oxidation by atmospheric oxygen, particularly at high storage temperature resulting in the development of off-flavours. Packing of spice oils and oleoresins is done in epoxy lined steel drums and high-density polythene containers. For certain oils and oleoresins, aluminium and stainless steel containers are used. Polyethylene terephthalate (PET) bottles, which possess very good odour barrier properties and food-grade high-molecular-weight high-density polyethylene (HMHDPE) containers are also used for storing essential oils and oleoresins. Most of the whole spices are protected by pericarp and the natural antioxidants present therein, and need less rigorous protection than ground spices. The packaging materials suitable for different spice products are listed in Table I.4.

Table I.4 Packaging in spices

Spice	Product	Type of packaging	Packing material
Black pepper	Whole pepper	Bulk	Gunny bags (burlap bags) polyethylene-lined double burlap bags.
	Whole pepper	Retail	HDPE pouches 200 gauge
	Ground pepper	Retail	Laminated heat stable aluminium foil (polyethylene coated) Moisture-proof cellulose film Double-lined polyethylene bags
Cardamom	Green cardamom	Bulk	Wooden boxes or tins lined with heavy gauge black polyethylene, metal foil or waterproof paper.
	Cardamom seed	Retail	Air-tight tin. Wooden chests lined with aluminium foil laminate
	Cardamom powder	Retail	Lacquered cans, PVDC and HDPE pouches
Ginger	Dry ginger	Bulk	Single/double gunny bags
Turmeric	Dry turmeric	Bulk	Double gunny bags
	Turmeric powder	Retail	Aluminium foil laminate
	Turmeric powder	Bulk	Fibreboard drums, multiwall bags and tin containers
Chilli	Dry chilli	Bulk	Wooden crate dunnage with a layer of matting
	Chilli powder	Retail	Plastic laminate and aluminium combination pouches with nitrogen gas. 3000 gauge low-density polyethylene pouches

Source: Pruthi (1993).

I.2 Herbs and spices as sources of natural colours and flavours

The food sector is now experiencing a trend back towards natural colourants due to changes in legislation and consumer preference as synthetic food colourants pose health hazards like cancer, asthma, allergy, hyperacidity and thyroidism. But low tinctorial power, poor stability (to changes in pH, oxygen, heat and light), low solubility, off-flavour and high cost limit the use of natural colours. These problems can be overcome by improving the traditional extraction methods using enzymes, microorganisms, super-critical CO_2, membrane processing and encapsulation techniques.

Before synthetic colours came into existence, spices like chilli, saffron, turmeric, etc., were used in Indian cuisines to add colour. The Central Food Technological Research Institute of India (CFTRI) has developed technology for the manufacture of certain natural food colours such as kokum (red) and chillies (red). Kokum contains 2–3% anthocyanin and is regarded as a natural colour source for acidic foods. Garcinol is the fat soluble yellow pigment isolated from rind of kokum fruit. Garcinol is added at 0.3% level to impart an acceptable yellow colour to butter. Colour components present in spices and natural shades available with spices are presented in Table I.5.

I.2.1 Sources of natural colours in spices

Paprika

The colour in paprika is due to carotenoids, namely capsanthin and capsorubin, comprising 60% of total carotenoids. Other pigments are cryptoxanthin, xeaxanthin, violaxanthin, neoxanthin and lutein. The outer pericarp of paprika is the main source of capsanthin and capsorubin. Indian paprika oleoresin is orange in colour which is less preferred in the international market. Oleoresin contains up to 50% capsorubin. Paprika oleoresin is insoluble in water whilst being readily soluble in vegetable oil and is made dispersible in water by the addition of polysorbate.

Applications are in sausages, cheese sauces, gravies, salad dressings, baked goods, snacks, icings, cereals and meat products.

Table I.5 Colour components in spices

Colour component	Tint	Spice
Carotenoid		
β-carotene	Reddish orange	Red pepper, mustard, paprika, saffron
Cryptoxantein	Red	Paprika, red pepper
Lutin	Dark red	Paprika, parsley
Zeaxanthin	Yellow	Paprika
Capsanthin	Dark red	Paprika, red pepper
Capsorubin	Purple red	Paprika, red pepper
Crocetin	Dark red	Saffron
Neoxanthin	Orange yellow	Parsley
Violaxanthin	Orange	Parsley, Sweet pepper
Crocin	Yellowish orange	Saffron
Flavonoids	Yellow	Ginger
Curcumin	Orange yellow	Turmeric
Chlorophylls	Green	Herbs

Source: Ravindran *et al.* (2002).

The ingredients of paprika colour are paprika oleoresin and refined vegetable oil. Stability is as follows:

Heat	good
pH (colour range)	pale pinkish
Light	good
Concentration	40000 IU

Turmeric

Curcumin is the golden-yellow pigment present in turmeric, regarded as the pure colouring principle with very little of flavour components. It is produced by crystallisation from the oleoresin and has a purity level of 95%. Pure curcumin is insoluble in water and hence is dissolved in food grade solvent and permitted emulsifier (Polysorbate 80). Curcumin gives a lemon-yellow colour in acidic pH. It is used at levels of 5–20 ppm. Curcumin is available in two basic forms, oleoresin and curcumin powder, both are used as food colourants.

The ingredients of turmeric colour (oil soluble) are curcumin and turmeric oleoresin Stability is as follows:

Heat	very good
pH (colour range)	greenish yellow to reddish yellow
Light	poor
Application	butter, margarine, cream desserts, fruit wine, bread, biscuit and cakes.

It is blended with other natural colours such as annatto and beetroot red for use in confectionary, ice cream, dairy products such as yoghurts.

Saffron

Saffron gives a wonderful golden colour to food but due to its powerful and distinctive flavour, it is prized in soups, stews, bread and rice dishes in many global cuisines. Saffron is perceived as luxurious and expensive and hence its use is restricted in foods. The intensive colour of saffron is caused by carotenoids, especially crocetine esters with gentobiose. Other carotenoids present are alpha and β carotene, lycopene and zeaxanthin.

I.2.2 Spices as sources of natural flavours

The increasing demand in developed countries for natural flavour offers tremendous potential for spice crops as sources of natural flavours. The main flavour compounds present in herbs and spices are presented in Table I.6. The recovery of essential oil and oleoresin from various spices and the major aromatic principles present in spices are illustrated in Table I.7. Extraction of oils and oleoresins is accomplished using a range of methods, including steam distillation, hydrocarbon extraction, chlorinated solvent extraction, enzymatic treatment and fermentation, and super-critical carbon dioxide extraction.

Carbon dioxide extraction from solid botanicals is now adopted on a commercial scale. The resulting essential oils have no solvent residue, fewer terpenes and enhanced black notes. Enzymatic treatment and fermentation of raw botanicals also result in greater yields and quality of essential oil. More recently, the use of genetic engineering

Table I.6 Important flavour compounds in spices

Spice	Important flavour compounds
Allspice	Eugenol, β-caryophyllene
Anise	(E)-anethole, methyl chavicol
Black pepper	Piperine, S-3 Carene, β-caryophyllene
Caraway	d-carvone, crone derivatives
Cardamom	α-terpinyl acetate, 1-80-cineole, linalool
Cinnamon, cassia	Cinnamaldehyde, eugenol
Chilli	Capsaicin, dihydro capsacin
Clove	Eugenol, eugeneyl acetate
Coriander	d-linalool, C10-C14-2-alkenals
Cumin	Cuminaldehyde, p-1,3-mentha-dienal
Dill	d-carvone
Fennel	(E)-anethole, fenchone
Ginger	Gingerol, Shogaol, neral, geranial
Mace	α-pinene, sabinene, 1-terpenin-4-ol.
Mustard	Ally isothiocynate
Nutmeg	Sabinene, α-pinene, myristicin
Parsley	Apiol
Saffron	Safranol
Turmeric	Turmerone, Zingeberene, 1,8-cineole
Vanilla	Vanillin, p-OH-benzyl-methyl ether
Basil, sweet	Methylchavicol, linalool, methyl eugenol
Bay laurel	1,8-cineole
Marjoram	e- and t-sabinene hydrates, terpinen-4-ol
Oregano	Carvacrol, thymol
Origanum	Thymol, carvacrol
Rosemary	Verbenone, 1-8-cineole, camphor, linanool
Sage, Clary	Salvial-4 (14)-en-1-one, linalool
Sage, Dalmation	Thujone, 1,8-cineole, camphor
Sage, Spanish	e- and t-sabinylacetate, 1,8-cineole, camphor
Savory	Carvacrol
Tarragon	Methyl chavicol, anethole
Thyme	Thymol, carvacrol
Peppermint	1-menthol, menthone, menthfuran
Spearmint	1-carvone, carvone derivatives

and recombinant DNA technology have resulted in *in vitro* production of natural esters, ketones and other flavouring materials. Cloning and single cell culture techniques are also of benefit to the flavourist.

I.2.3 Herbs and spices as medicinal plants

The medicinal properties of spices have been known to mankind from time immemorial. Spices were used extensively in the traditional systems of medicines such as Ayurveda, Sidha and Unani. In the recent past, there has been increasing interest in the biological effects of spices as they are safe and cause no side effects to humans. Extensive studies are going on in developed countries for the separation of medicinal components from spices and evaluation of their biological properties. A classic example for such study is the Piperine alkaloid separated from black pepper and marketed as Bioperine (98% pure piperine). This alkaloid could increase bioavailability of certain drugs and nutrients like beta carotene. The medicinal properties of spices are summarised in Table I.8.

Table I.7 Recovery of essential oil and oleoresin from spices and the major aromatic principle

Spice	Essential oil (%)	Aromatic principle	Oleoresin (%)
Black pepper	1–4.0	Terpin hydrate	10–13
Cardamom (small)	6–10	α–terpinyl acetate 1,8–cineole	10–12
Cardamom (large)	1–3	1,8–cineole	–
Ginger	1–2.5	Zingiberine	5–10
Turmeric	2–6	Turmerone	8–10
Nutmeg	7–16	Myristicine Elemicin	10–12
Clove	16–18	Eugenol	20–30
Cinnamon	1–3	Cinnamaldehyde (bark oil) Eugenol (leaf oil) Camphor (root bark oil)	10–12
Allspice	1–3 (leaf oil) 3–4.5 (berry oil)	Eugenol	–

Table I.8 Medicinal properties of spices

Spice	Medicinal property
Black pepper	Carminative, antipyretic, diuretic, anthelminthic, antiflammatory and antiepileptic
Cardamom	Antidepressive, carminative, appetizer, diuretic
Ginger	Carminative, anti nauseant, diuretic, antiflatulence, antihistaminic, aphrodisiac and cholesterol lowering
Turmeric	Carminative, antibiotic, antiflatulence, antiseptic and anti-inflammatory
Garlic	Antimicrobial, diuretic, diaphoretic, antiflatulence, cholesterol lowering and anti-inflammatory
Clove	Antiflatualnce, analgesic, stimulant, carminative and antinauseant
Nutmeg	Stimulant, carminative, astringent, aphrodisiac, anti-inflammatory
Cinnamon	Stiumlant, Carminative, astringent, aphrodisiac, anti-inflammatory
Chilli	Carminative and antirheumatic
Saffron	Stimulant, stomachic and anticarcinogenic
Allspice	Stimulant, digestive and carminative
Basil, sweet	Stomachic, anthelminitic, diaphoretic, expectorant, antipyretic carminative, stimulant, diuretic, demulcent
Bayleaves (laurel)	Stimulant, narcotic
Caraway	Stomachic, carminative, anthelminitic, lactagogue
Celery	Stimulant, tonic, diuretic, carminative, emmenagogue, anti-inflammatory
Chive	Stimulant, diuretic, expectorant, aphrodisiac, emmenegogue, anti-inflammatory
Coirander	Carminative, diuretic, tonic, stimulant, stomachic, refrigerent, aphrodisiac, analgesic, anti-inflammatory
Cumin	Stimulant, carminative, stomachic, astringent and antiseptic
Dill	Carminative, stomachic, antipyretic
Fennel	Stimulant, carminative, stomachic, emmenagogue
Fenugreek	Carminative, tonic, aphrodisiac
Leek	Stimulant, expectorant
Marjoram	Carminative, expectorant, tonic, astringent
Mint (peppermint)	Stimulant, stomachic, carminative, antiseptic
Mint (spearmint)	Stimulant, carminative and antispasmodic
Oregano	Stimulant, carminative, stomachic, diuretic, diaphoretic and emmenagogue
Parsley	Stimulant, diuretic, carminative, emmenagogue, antipyretic, anti-inflammatory
Rosemary	Mild irritant, carminative, stimulant, diaphoretic
Sage	Mild tonic, astringent, carminative
Tarrgon	Aperient, stomachic, stimulant, febrifuge
Thyme	Antispasmodic, carminative, emmenagogue, anthelmintic, spasmodic, laxative, stomachic, tonic, vermifuge

This volume is the third in the series *Handbook of herbs and spices* and has two parts. The first part deals with general aspects referred to the industry such as quality spice production, quality assurance systems, decontamination techniques, packaging, spices as sources of natural colours and flavours, effect of Agreement on Agriculture on spice production and export, etc. The second part deals with detailed information on individual spices. It is hoped that this book will form a good reference source for those who are involved in the study, cultivation, trade and use of spices and herbs.

I.3 References and further reading

APARNATHI, K.D. and BORKHATRIYA, V.N. 1999. Improved extraction and stabilization of natural food colourants. *Indian Fd. Ind.* 18(3): 164–168.

DOWNHAM, A. and COLLINS, P. 2000. Colouring our foods in the last and next millennium. *Int. J. Fd. Sci. Technol*. 35(1): 5–22.

HENRY, B. 1998. Use of capsicum and turmeric as natural colours in the food industry. *Indian Spices* 35(3): 9–11.

PETER, K.V. (ed.) 2001. *Handbook of Herbs and Spices*, Vol. I. Woodhead Publishing Limited, Abington, UK.

PETER, K.V. (ed.) 2004. *Handbook of Herbs and Spices*, Vol. II. Woodhead Publishing Limited, Abington, UK.

PRUTHI, J.S. 1993. *Major spices of India – Crop Management Post-harvest Technology*. ICAR, New Delhi.

PRUTHI, J.S. 2000. *Minor Spices of India – Crop Management and Post-harvest Technology*. ICAR, New Delhi.

PURSEGLOVE, J.W., BROWN, E.G., GREEN, C.L. and ROBBINS, S.R.J. 1981. *Spices* Vols I and II (Tropical Agriculture Series), Longman, London.

RAVINDRAN, P.N., JOHNY, A.K. and NIRMAL BABU, K. 2002. *Spices in our daily life*. Satabdi Smaranika Vol. 2 Arya Vaidya Sala, Kottakkal, Kerala, India.

SHARMA, A., KOHLI, A.K., SHARMA, G. and RAMAMOORTHY, N. 2003. Radiation hygienization of spices and dry vegetable seasonings. *Spice India* 1(1): 26–29.

SPICES BOARD OF INDIA. 2001. *Guidelines for production of organic spice in India*. Spice Board, Kochi, Kerala, India.

Index

Contents