



Meat products handbook

Practical science and
technology

Gerhard Feiner



QUALITY
INGREDIENTS



More Taste. More Pleasure.



WP

Meat products handbook

Practical science and technology

Gerhard Feiner



QUALITY
INGREDIENTS



More Taste. More Pleasure.



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
© 2006, Woodhead Publishing Limited
The author has asserted his moral rights.

This book contains information obtained from authentic and highly regarded sources. Reprinted material is quoted with permission, and sources are indicated. Reasonable efforts have been made to publish reliable data and information, but the author and the publishers cannot assume responsibility for the validity of all materials. Neither the author nor the publishers, nor anyone else associated with this publication, shall be liable for any loss, damage or liability directly or indirectly caused or alleged to be caused by this book.

Neither this book nor any part may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, microfilming and recording, or by any information storage or retrieval system, without permission in writing from Woodhead Publishing Limited.

The consent of Woodhead Publishing Limited does not extend to copying for general distribution, for promotion, for creating new works, or for resale. Specific permission must be obtained in writing from Woodhead Publishing Limited for such copying.

Trademark notice: Product or corporate names may be trademarks or registered trademarks, and are used only for identification and explanation, without intent to infringe.

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: 978-1-84569-050-2 (book)
Woodhead Publishing ISBN-10: 1-84569-050-8 (book)
Woodhead Publishing ISBN-13: 978-1-84569-172-1 (e-book)
Woodhead Publishing ISBN-10: 1-84569-172-5 (e-book)
CRC Press ISBN-13: 978-0-8493-8010-5
CRC Press ISBN-10: 0-8493-8010-3
CRC Press order number: WP8013

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.

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

Meat products handbook

Related titles:

Improving the safety of fresh meat

(ISBN-13: 978-1-85573-955-0; ISBN-10: 1-85573-955-0)

It is widely recognized that food safety depends on effective intervention at all stages in the food chain. This authoritative and comprehensive book summarizes the wealth of research on reducing microbial and other hazards in fresh meat.

Lawrie's meat science – Seventh edition

(ISBN-13: 978-1-84569-159-2; ISBN-10: 1-84569-159-8)

Widely regarded as a standard work, this famous book provides an authoritative introduction to meat science, covering such themes as the growth and structure of muscle and its conversion to meat, storage and preservation, and eating quality.

Meat processing: improving quality

(ISBN-13: 978-1-85573-583-5; ISBN-10: 1-85573-583-0)

This important book summarizes research on ways of analysing and measuring aspects of meat quality such as flavour, quality and nutritional content, together with developments which improve quality in such areas as high pressure processing, automation, chilling and freezing.

Details of these books and a complete list of Woodhead titles can be obtained by:

- visiting our web site at www.woodheadpublishing.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 Ltd, Abington Hall, Abington, Cambridge CB1 6AH, England)

Preface

Several years ago it became apparent to me that there was a need for an all-in-one book about meat processing which clearly outlined the parameters to be considered during the various steps of processing. However, in order to understand processing properly, the basic principles of meat science and the composition and function of additives have to be understood first. Therefore these would have to be covered in detail in the book as well.

The purpose of this book is to give clear and helpful guidelines to professionals within the meat-processing industry, such as technical, production, quality control and research and development managers. Butchers handling meat and meat products on a daily basis will also greatly benefit from it, as will undergraduate and postgraduate students, who will, I hope, find the book an invaluable tool for their studies.

Having worked all over the world in the meat-processing industry, conducting seminars for customers as well as lecturing at a university, I was often asked about the availability of such an all-in-one book. Books available today focus either on meat science or on manufacturing at various levels of detail but not on both at the same time. As such, this book combines a scientific and yet still hands-on approach and covers all three major aspects of meat technology. These are the raw materials themselves, the 'world' of additives and, finally, the technologies used to combine them. Microbiology related to meat and meat products is also discussed as it plays an integral role in the production process and in the safety and shelf life of meat and meat products.

Acknowledgements

This book summarizes both my practical and my theoretical knowledge gained from working within the meat industry in several countries. My theoretical knowledge gained over the years is the result of both having been taught by and having worked with extremely knowledgeable people during my study of the Master Butcher Diploma and especially during my study of Meat Technology in Kulmbach (Germany). Therefore, I want to express deep gratitude to those who taught me over all those years, namely Titus Kaibic, Dipl.-Ing. Thomas Eberle, Dr Gerhard Hartmann, Dr Siegfried Guenther, Dr Fredi Schwaegele, Dr Guenther Hammer, Dipl.-Ing. Hans-Georg Hechelmann, Dr Klaus Fischer, Professor Lothar Leistner, Dr Herman Hecht, Professor Christoph Augustini, Dr Wolfgang Schneider, Dr Ulrike Fischer-Naegele, Dr Peter Braun, Dr Andrea Maurer, Udo Kuenzel, Barry Doesburg and Dr Joe Chen. I also want to thank all those people whom I no longer even remember who have given me ideas and help over the years. However the biggest thank you must go to my patient wife. She endured many lonely months whilst I wrote this book and has been a wonderful support during the research, writing and editing of the book.

During the course of my studies several books were of great help, namely: Breuer, H., *dtv-Atlas zur Chemie II: Organische Chemie und Kunststoffe*, 5th edition, Deutscher Taschenbuch Verlag, München, 1992.

Kulmbacher Reihe, Band 2, *Beiträge zur Chemie und Physik des Fleisches*, Foerderergesellschaft der Bundesanstalt fuer Fleischforschung, Kulmbach, 1981 (articles by K. Hofmann, by K. Potthast, by R. Hamm, by C. Fischer, by K.O. Honikel and by L. Toth).

Kulmbacher Reihe, Band 4, *Technologie der Brühwurst*, Foerderergesellschaft der Bundesanstalt fuer Fleischforschung, Kulmbach, 1984 (articles by G.F. Hammer, by F. Worth and by P.-G. Klettner).

Kulmbacher Reihe, Band 5, *Mikrobiologie und Qualität von Rohwurst und Rohschinken*, Foerderergesellschaft der Bundesanstalt fuer Fleischforschung, Kulmbach, 1985 (articles by W. Rödel, by F.-J. Lücke and by H. Hechelmann).

- Kulmbacher Reihe*, Band 6, *Chemisch-physikalische Merkmale der Fleischqualität*, Foerderergesellschaft der Bundesanstalt fuer Fleischforschung, Kulmbach, 1986 (article by K.O. Honikel, by H. Hecht and by K. Potthast).
- Kulmbacher Reihe*, Band 8, *Technologie der Kochwurst und Kochpökelware*, Foerderergesellschaft der Bundesanstalt fuer Fleischforschung, Kulmbach, 1988 (articles by G.F. Hammer, by F. Wirth, by W.-D. Müller, by A. Stiebing and by P.-G. Klettner).
- Kulmbacher Reihe*, Band 10, *Sichere Produkte bei Fleisch und Fleischerzeugnissen*, Foerderergesellschaft der Bundesanstalt fuer Fleischforschung, Kulmbach, 1990 (articles by L. Leistner, by H. Hechelman and R. Kasprowiak, by R. Geisen, by F.-K. Lücke and by L. Kröckel).
- Kulmbacher Reihe*, Band 11, *Qualitätssicherung im Fleischbereich*, Foerderergesellschaft der Bundesanstalt fuer Fleischforschung, Kulmbach, 1992 (article by K. Potthast).
- Müller, G., *Grundlagen der Lebensmittelmikrobiologie*, Fachbuchverlag (on behalf of Dr. Dietrich Steinkopff Publishing), Leipzig, 1986.
- Prändl, O., Fischer, A., Schmidhofer, T., and Sirell, H.-J. *Fleisch*, Eugen Ullmer, Stuttgart, 1988.

Disclaimer

All information in this book is based on practical knowledge gained by the author whilst working in factories as well as theoretical knowledge gained during his studies and should not be used as the basis for any legal claims. Hence, all information stated is not intended to credit, or discredit, any manufacturer of equipment or additives and is based purely on the opinion of the author.

Abbreviations

ADP	adenosine diphosphate
ATP	adenosine triphosphate
BHA	butylated hydroxyanisole
BHT	butylated hydroxytoluene
BSE	bovine spongiform encephalopathy
CCP	critical control point
cfu	colony-forming unit
CL	chemically lean
CJD	Creutzfeldt–Jakob disease
CoA	coenzyme A
CP	creatine phosphate
CU	colour unit
DE	dextrose equivalent
DFD	dark firm dry
DNA	deoxyribonucleic acid
ETC	electron transfer chain
FAD	flavin–adenine dinucleotide
FFA	free fatty acid
GDL	glucono- δ -lactone
GI	glycaemic index
GM	genetically modified
GMO	genetically modified organism
GTP	guanosine triphosphate
HACCP	hazard analysis critical control point
HDL	high-density lipoprotein
HLB	hydrophilic lipophilic balance
HVP	hydrolysed vegetable protein
IEP	isoelectric point
IgE	immunoglobulin E
IP	identity preserved
LBG	locust bean gum

LDL	low-density lipoprotein
3-MCPD	3-monochloropropane-1,2-diol
MDM	mechanically deboned meat
MEM	moisture-enhanced meat
MSG	monosodium glutamate
MSM	mechanically separated meat
NAD	nicotinamide adenine dinucleotide
NFSS	non-fermented sliceable salami
OSI	oxidative stability index
PAH	polycyclic aromatic hydrocarbon
PCR	polymerase chain reaction
PHM	pork head meat
PPP	post-pack pasteurization
PSE	pale soft exudative
PV	peroxide value
RH	relative humidity
RSE	red soft exudative
SF _{FM}	solubility factor in fatty meat
SF _M	solubility factor in lean meat
SMBS	sodium metabisulphite
SPR	sarcoplasmic reticulum
STPP	sodium tripolyphosphate
TBA	thiobarbituric acid
TG	transglutaminase
TPC	total plate count
TSC	trisodium citrate
TVP	textured vegetable protein
UV	ultraviolet
VL	visual lean
WBC	water-binding capacity
WHC	water-holding capacity
WME	warm-meat effect
WOF	warmed-over flavour

Contents

<i>Preface</i>	<i>xv</i>
<i>Acknowledgements</i>	<i>xvii</i>
<i>Disclaimer</i>	<i>xix</i>
<i>List of abbreviations</i>	<i>xxi</i>
Part I Meat composition and additives	1
1 The protein and fat content of meat	3
1.1 Amino acids	4
1.2 Proteins	7
1.3 Collagen	9
1.4 Muscle physiology	10
1.5 Flavour of meat	15
1.6 Principles of muscle contraction and relaxation	18
1.7 Enzymes in meat	20
1.8 Fat	21
1.9 Rancidity of fat	27
1.10 Low-density lipoprotein and high-density lipoprotein cholesterol	31
1.11 Nutritional value of meat and other protein-rich food	32
2 The biochemistry of meat	33
2.1 Biochemical processes in meat pre-slaughter	33
2.2 Biochemical processes in meat post-slaughter (rigor mortis)	38
3 The tenderness of fresh meat	42
3.1 Ageing of meat for enhancing tenderness	42
3.2 Enzymes used for enhancing the tenderness of meat	45
4 Definitions of terms used in meat science and technology	46
4.1 Pale soft exudative (PSE) meat, red soft exudative (RSE) meat, dry firm dark (DFD) meat and 'normal' meat	46

4.2	Mechanically deboned meat and mechanically separated meat	50
4.3	Hot boning of meat: 'warm-meat effect'	53
4.4	Thaw rigor	54
4.5	Cold shortening	55
4.6	Electrical stimulation	57
4.7	Freezing and thawing of meat	58
4.8	Freezer burning	64
4.9	pH value	65
4.10	A_w value (water activity)	66
4.11	E_h value (redox potential)	67
4.12	Condensation water	68
4.13	Maillard reaction	70
4.14	Caramelization	70
4.15	Conductivity of meat	71
5	Additives: phosphates, salts (sodium chloride and potassium chloride, citrate, lactate) and hydrocolloids	72
5.1	Phosphates	73
5.2	Salts (sodium chloride and potassium chloride, citrate, lactate)	77
5.3	Hydrocolloids	83
6	Additives: proteins, carbohydrates, fillers and other additives	89
6.1	Proteins	89
6.2	Carbohydrates	98
6.3	Fillers: maltodextrin, flour, wheat fibre, konjac, cereal binder and rusk	109
6.4	Preservatives in meat products	112
6.5	Monosodium glutamate	115
6.6	Ribonucleotide and other flavour enhancers	116
6.7	Water	116
6.8	Spices and spice extracts	118
6.9	Hydrolysed vegetable protein	122
6.10	Antioxidants	123
6.11	Natural smoke	125
6.12	Liquid smoke	129
6.13	Colours in meat products	131
6.14	Whitening (bleaching) of meat	133
6.15	Glucono- δ -lactone	134
6.16	Citric acid	134
6.17	Emulsifiers in meat products	135
6.18	Alginate for re-formed meat	137
6.19	Enzymes for re-formed meat and other meat products	138

6.20	Blood-derived products for re-formed meat	139
6.21	Allergens in meat products	139
7	Colour in fresh meat and in cured meat products	142
7.1	Retention of colour in fresh meat and uncured meat products	142
7.2	Nitrite and nitrate	147
7.3	Mechanism of colour development in cured meat products	150
7.4	Colour enhancers	153
7.5	Measuring colour: the $L^*-a^*-b^*$ system	156
	Part II Technologies for particular meat products	159
8	Whole-muscle brine-injected products	161
8.1	Selection and preparation of raw materials	162
8.2	Selection of additives	166
8.3	Calculating brine composition and injection levels	175
8.4	Manufacturing technology	178
8.5	Summary of critical production issues	209
9	Typical whole-muscle brine-injected products from around the world	211
9.1	Bacon (Australia)	211
9.2	Bacon (New Zealand)	212
9.3	Cooked ham on the bone (Australia)	213
9.4	Champagne ham (Australia)	214
9.5	Master ham (Austria)	214
9.6	Kasseler (Austria and Germany)	215
9.7	Virginia ham (Australia)	215
9.8	Bacon (England)	216
9.9	Bacon (USA)	217
9.10	Pastrami (USA and Australia)	217
9.11	Roast pork (Australia)	218
9.12	Beef bacon	219
10	Re-formed products: non-injection methods for adding brine	220
10.1	Selection and preparation of raw materials	221
10.2	Selection of additives	222
10.3	Manufacturing technology	224
10.4	Summary of critical production issues	232
11	Typical re-formed products from around the world using non-injection methods for adding brine	234
11.1	Sandwich ham (Australia)	234
11.2	Chicken loaf	235
11.3	Delicates ham (Austria)	237

12	Cooked sausages	239
12.1	Selection of raw materials	240
12.2	Production and use of pork or chicken skin emulsion in cooked sausages	246
12.3	Production and use of fat emulsion in cooked sausages ..	249
12.4	Selection of additives	251
12.5	Manufacturing technology	257
12.6	Emulsifying in a grinder-emulsifier system	273
12.7	Filling	276
12.8	Smoking, cooking and cooling	278
12.9	Slicing, packing and storage	283
12.10	Summary of critical production issues	285
13	Typical cooked sausage products from around the world	287
13.1	Frankfurters (Austria and Germany)	287
13.2	Frankfurters (Philippines)	287
13.3	Frankfurters (South Africa)	288
13.4	Frankfurters (Malaysia)	289
13.5	Chicken sausage with oil	289
13.6	Cooked bratwurst	290
13.7	Hunter sausage	291
13.8	Beer ham (Germany)	291
13.9	Luncheon meat (Australia)	292
13.10	Weisswurst (Bavarian white sausage) (Germany)	292
13.11	Mortadella (Italy)	293
13.12	Low-fat frankfurters	294
13.13	Bavarian meat loaf (Austria and Germany)	294
13.14	Meatballs (Asia)	295
14	Fresh sausages	297
14.1	Selection of raw materials	298
14.2	Selection of additives	299
14.3	Manufacturing technology	302
14.4	Summary of critical production issues	309
15	Typical fresh sausage products from around the world	310
15.1	Nuremberg bratwurst (Germany)	310
15.2	Boerewors (South Africa)	311
15.3	Barbecue sausage (Australia)	311
15.4	Chicken sausage (Australia)	312
15.5	Merguez (France)	312
15.6	Cumberland sausage (Great Britain)	312
15.7	English breakfast sausages (Great Britain)	313
16	Raw fermented salami	314
16.1	Selection of raw materials	315
16.2	Selection of additives and starter cultures	322

16.3	Manufacturing technology	334
16.4	Summary of critical production issues	375
17	Typical raw fermented salami products from around the world	376
17.1	Hungarian salami	376
17.2	Kantwurst (Austria)	377
17.3	Lup cheong (PR China)	378
17.4	Cacciatore (Italy)	379
17.5	Milano salami (Italy)	379
17.6	Summer sausage (USA)	380
17.7	Sucuk (Turkey)	380
17.8	Chorizo (Spain)	381
17.9	Fuet (Spain)	381
17.10	Pepperoni (USA)	381
18	Semicooked and fully cooked fermented salami	383
18.1	Manufacturing technology for semicooked fermented salami	383
18.2	Manufacturing technology for fully cooked fermented salami	384
19	Non-fermented salami	386
19.1	Selection and preparation of raw materials	386
19.2	Selection of additives	387
19.3	Manufacturing technology	388
19.4	Summary of critical production issues	395
20	Typical non-fermented salami products from around the world	396
20.1	Polish salami (Austria)	396
20.2	Cheese salami (Austria)	397
20.3	Kransky (Slovenia)	397
20.4	Vienna salami (Austria)	398
20.5	Cabana (or cabanossi) (Austria and Australia)	398
21	Spreadable raw fermented sausage	400
21.1	Selection of raw materials	400
21.2	Selection of additives	402
21.3	Manufacturing technology	404
21.4	Summary of critical production issues	413
22	Typical raw fermented sausage products from around the world	414
22.1	Teewurst (finely cut tea sausage) (Austria and Germany)	414
22.2	Coarse onion mettwurst (Austria and Germany)	415

23	Cured air-dried meat products	417
23.1	Selection and preparation of raw materials	417
23.2	Selection of additives	420
23.3	Manufacturing technology	422
23.4	Summary of critical production issues	441
24	Typical cured air-dried meat products from around the world	442
24.1	Parma ham (Italy)	442
24.2	Pancetta (Italy)	444
24.3	Parma coppa (Italy)	444
24.4	Black Forest ham (Germany)	445
24.5	Serano ham (Spain)	445
24.6	Biltong (South Africa)	446
24.7	Pastirma (Turkey)	447
24.8	Bündner fleisch (dried beef 'bündner style') (Switzerland)	447
24.9	Beef jerky (USA)	448
24.10	Rou gan and shafu (PR China)	449
25	Spreadable liver sausage and liver pâté	451
25.1	Selection and preparation of raw materials	451
25.2	Selection of additives	457
25.3	Manufacturing technology using precooked hot materials (conventional method)	459
25.4	Production of liver pâté	472
25.5	Summary of critical production issues for liver sausage ...	474
26	Typical spreadable liver sausage and liver pâté products from around the world	476
26.1	Fine veal liver sausage (Austria)	476
26.2	Fine liver sausage (Austria and Germany)	477
26.3	Coarse liver sausage (Austria and Germany)	477
26.4	Fine liver sausage (Russia and South Africa)	477
26.5	Coarse brandy liver pâté in a pastry cover	478
26.6	Fine pepper-chicken liver pâté in a mould	478
26.7	Pâté de campagne (France)	479
26.8	Pâté de viande (France)	479
26.9	Rillete porc et oie (France)	479
26.10	Pâté de Bretons (France)	480
27	Burgers, patties and crumbed products	481
27.1	Selection of raw materials	482
27.2	Selection of additives	483
27.3	Manufacturing technology	486
27.4	Summary of critical production issues	491
27.5	Crumbed products	492