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Food process modelling

**Edited by L. M. M. Tijskens, M. L. A. T. M. Hertog
and B. M. Nicolai**



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Preface

Ever since man walked on the face of this earth, he has consumed food to survive, to maintain his body and mind, and later for pleasure too. In the early days, he had to gather his food wherever he found it. Gradually man started to understand how to grow and cultivate his own food, and he gained more and more control over his environment. All this time, man was curious about what he observed and the mechanisms behind it, longing to understand what happened, what happens to himself, to his food and to his environment.

In the current age of highly developed science and technology, the modern aid to analyse, interpret and understand our surrounding world is modelling. Modelling can be regarded as bringing together the concepts developed by product and process experts into a coherent and consistent entity. By subsequently translating such conceptual models into their mathematical equivalents and by implementing these into computer programs, such models can be used for quantitative analyses and, ultimately, for making predictions. Sometimes expert and modeller are united in one person. In that situation, dedicated models will emerge. When they are different people, the model will often include views that are more generic in nature.

Modelling can be conducted on an almost infinite number of levels, reflecting different degrees of real life, ranging from the purely theoretical to the completely empirical. Nowadays modelling is used in almost every discipline by an ever-increasing number of people. Few of these modellers had a dedicated education in this area, and most of them had to learn the trade the hard way, in daily practice by trial and error, without being aware of the pitfalls of this powerful tool.

In this book, we have attempted to bring some order and rules to the jungle of techniques available for modelling the processes and phenomena that play a part

in our daily food. We need to realise that what we taste and perceive in our food and that what we like in our food, is the result both of processes that occur naturally in our food and processes that we apply to it. On top of that, the techniques used for modelling are applied processes as well. The title of this book, *Food Process Modelling*, has, therefore, to be understood in terms of those three types of processes:

- Processes occurring in food
- Processes applied to food
- Processes applied to model food behaviour.

This book is subdivided into five major parts, each covering a selected area from theory or practice, either involving modelling techniques, or involving particular food processes to which the models are applied.

In Part I the principles and procedures of fundamental, deductive approaches of modelling are explained and discussed. The essence of deductive modelling is the conversion of theories and concepts into mathematical and computer formulations, virtually without applying information contained in the measured data. Data are only used to calibrate and validate the developed models.

In Part II the principles and procedures of empirical, inductive approaches of modelling are explained and discussed. The essence of inductive modelling is to extract as much useful information contained in the measured data as possible, without *a priori* knowledge of the processes involved. Data, for this type of modelling, are the only source of information available. Of course, reality is never that black or white, so models are not purely black or white either. In each of the chapters in Parts I and II some combination of the two types of modelling approaches will be found.

In Parts III and IV of this book, practical examples are provided in the area of production, processing and storage of fresh foods. Models discussed range from almost purely deductive to almost purely inductive. Part III covers the agricultural production, from fruits and vegetables to the dairy and meat sectors. Part IV looks at a range of processing technologies.

The last part of the book discusses aspects of quality and safety. It is not dedicated to one product or process, but to the conglomerate of actions the food industry has to take to bring food to consumers. The emphasis lies on quality and safety throughout the entire food chain, from production, through storage, transport and handling to retail, and finally to the consumer's place to maintain his body and mind, and hopefully to be enjoyed as well.

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Contents

<i>Preface</i>	xi
Part I The principles of modelling: fundamental approaches	1
1 The power and pitfalls of deductive modelling	3
<i>B. P. Hills, Institute of Food Research, Norwich</i>	
1.1 Introduction	3
1.2 Deductive modelling and process optimization	5
1.3 Modelling the keeping-quality and shelf-life of foods	8
1.4 Deductive modelling of flavour release from foods	15
1.5 Future trends	17
1.6 References	17
2 Problem decomposition	19
<i>M. Sloof, Everest B. V., 's-Hertogenbosch</i>	
2.1 Introduction	19
2.2 Decomposition in information technology	20
2.3 Modelling food processes	22
2.4 Benefits for modelling food processes	31
2.5 Future trends	32
2.6 References	34
3 Kinetic modelling	35
<i>M. A. J. S. van Boekel, Wageningen University, and L. M. M. Tijskens, ATO-BV, Wageningen</i>	
3.1 Introduction	35
3.2 Key principles and methods	36

3.3	Areas of application	54
3.4	Pros and cons of kinetic modelling	56
3.5	Future trends	57
3.6	References	57
4	The modelling of heat and mass transfer	60
	<i>B. M. Nicolai, P. Verboven, N. Scheerlinck, Katholieke Universiteit Leuven</i>	
4.1	Introduction	60
4.2	The diffusion equation	61
4.3	The Navier-Stokes equations	64
4.4	Heat and mass transfer in porous media: Luikov's equations ..	69
4.5	Numerical methods	72
4.6	Conclusions	81
4.7	Acknowledgements	81
4.8	References	81
5	Combined discrete/continuous modelling	87
	<i>R. W. Sierenberg</i>	
5.1	Introduction: the big gap	87
5.2	The power of parallel processes	90
5.3	The 'world view' of system theory	93
5.4	Combined modelling	97
5.5	Pitfalls	98
5.6	Conclusions and trends	100
Part II	The principles of modelling: empirical approaches	103
6	The power and pitfalls of inductive modelling	105
	<i>F. Verdenius, ATO BV, Wageningen and L. Hunter, University of Colorado, School of Medicine</i>	
6.1	Introduction	105
6.2	Key principles and methods	108
6.3	Pros and cons of inductive modelling	130
6.4	Future trends	132
6.5	References	134
7	Data mining	137
	<i>G. Holmes and T. C. Smith, University of Waikato, Hamilton</i>	
7.1	Introduction	137
7.2	Input characteristics	140
7.3	Data engineering methods	141
7.4	Output representations	142
7.5	Data mining methods	145
7.6	Output evaluation	152
7.7	Concluding remarks	153
7.8	References	154

8 Modelling and prediction in an uncertain environment	156
<i>J. F. Van Impe, K. Bernaerts, A. H. Geeraerd, F. Poschet and K. J. Versyck, Katholieke Universiteit Leuven</i>	
8.1 Introduction	156
8.2 Data (pre)processing	158
8.3 Model structure characterisation	161
8.4 Model parameter estimation	164
8.5 Model output uncertainty assessment	172
8.6 Conclusions	174
8.7 Appendix A	175
8.8 Appendix B	176
8.9 References	177
Part III Applications: agricultural production	181
9 Yield and quality prediction of vegetables: the case of cucumber	183
<i>L. F. M. Marcelis, Plant Research International, Wageningen</i>	
9.1 Introduction	183
9.2 Key principles and methods	184
9.3 Areas of application	189
9.4 How generic are crop models?	194
9.5 Some future trends	195
9.6 Summary	196
9.7 References	197
10 Modelling and management of fruit production: the case of tomatoes	201
<i>C. Gary and M. Tchamitchian, INRA, Avignon</i>	
10.1 Introduction: the contexts of tomato production	201
10.2 Processes and methods of modelling tomato crops	203
10.3 Areas of application	211
10.4 Discussion of the methods and future trends	221
10.5 References	223
11 Dairy production	230
<i>C. F. E. Topp, Scottish Agricultural College, Ayr</i>	
11.1 Introduction	230
11.2 The model structure	231
11.3 Conclusions	247
11.4 Acknowledgements	248
11.5 References	248
12 Beef cattle production	253
<i>K. G. Rickert, University of Queensland, Gatton</i>	
12.1 Introduction	253
12.2 Elements of beef cattle production	254
12.3 Challenges for modellers	258

12.4	Simple model of herd structure	265
12.5	Future developments	268
12.6	References	269
Part IV Applications: processing technologies		273
13	The use of models in process development: the case of fermentation processes	275
	<i>J. J. M. Hofmeester, DSM Food Specialties, Moorebank</i>	
13.1	Introduction	275
13.2	What is a fermentation process?	276
13.3	Models used during process development	278
13.4	Future trends	287
14	Improving modified atmosphere packaging through conceptual models	288
	<i>M. L. A. T. M. Hertog, Massey University, Palmerston North, and N. H. Banks, Zespri Innovation, Mt Maunganui South</i>	
14.1	Introduction	288
14.2	Key principles and methods	289
14.3	Areas of application	303
14.4	Pros and cons	305
14.5	Future trends	306
14.6	References	307
15	Modelling thermal processes: cooling and freezing	312
	<i>Q. T. Pham, University of New South Wales, Sydney</i>	
15.1	Introduction	312
15.2	Modelling product heat load during cooling	314
15.3	Modelling product heat load during freezing	316
15.4	Modelling foods with complex shapes	317
15.5	Numerical solution of the heat conduction equation with phase change	320
15.6	Modelling combined heat and mass transfer	324
15.7	Estimation of transfer coefficients	328
15.8	Application of models	331
15.9	Summary and future developments	333
15.10	References	335
16	Modelling thermal processes: heating	340
	<i>S. Bakalis, P. W. Cox and P. J. Fryer, University of Birmingham</i>	
16.1	Introduction	340
16.2	Processing of packed and solid foods	343
16.3	Continuous heating and cooling processes	349
16.4	Heat generation methods: ohmic and microwave heating	354
16.5	Developments in the field	358
16.6	References	360

Part V Applications: safety and quality in the food chain	365
17 Modelling food quality	367
<i>E. C. Wilkinson and L. M. M. Tijskens, ATO-BV, Wageningen</i>	
17.1 Introduction	367
17.2 Key principles and methods	368
17.3 Areas of application	376
17.4 Pros and cons and future trends	379
17.5 References	380
18 Modelling microbiological safety	383
<i>J. Baranyi, Institute of Food Research, Norwich and C. Pin, Universidad Complutense de Madrid</i>	
18.1 Introduction	383
18.2 Developing mathematical models	384
18.3 Modelling the effect of environmental factors on the growth parameters	389
18.4 Model validation	395
18.5 Available software packages	397
18.6 Modelling bacterial growth by a stochastic birth process: <i>a candidate for future research</i>	398
18.7 References	400
19 Modelling the use of time-temperature indicators in distribution and stock rotation	402
<i>P. S. Taoukis, National Technical University of Athens</i>	
19.1 Introduction	402
19.2 Definitions and history of TTI	403
19.3 Food quality modelling	411
19.4 TTI response modelling – application scheme	413
19.5 Shelf-life monitoring in distribution	418
19.6 Optimized distribution and stock rotation system	422
19.7 Future developments	427
19.8 References	428
20 Modelling the management of distribution centres	432
<i>R. A. C. M. Broekmeulen, Eindhoven University of Technology</i>	
20.1 Introduction	432
20.2 Characteristics of perishables	433
20.3 Maintaining keeping quality with a slot plan	437
20.4 Construction of a slot plan	442
20.5 Summary	444
20.6 References	446
21 Concepts of chain management and chain optimisation	448
<i>L. M. M. Tijskens, A. C. Koster, J. M. E. Jonker, ATO BV, Wageningen</i>	
21.1 Introduction	448
21.2 Key principles and methods	449

x Contents

21.3	Food supply chains	456
21.4	Problems and issues of global sourcing	459
21.5	Practical application of supply chain management: efficient consumer response	461
21.6	Conclusions	466
21.7	References	467
<i>Appendix: Notation</i>		470
<i>Index</i>		484

Part I

The principles of modelling: fundamental approaches

Introduction

In modern science, all simple problems have been solved by now. What remains are problems that are so complex, one cannot unravel their mysteries by simple experiments and deductions. To tackle these complex problems, we have to decompose them into their constituting processes and each of these processes has to be studied, analysed and modelled separately. As a consequence, experimental research and analysis of resulting data relies more and more on theoretical, fundamental and generic models. These types of models are deduced from views and theories currently available. These deductive models possess the intrinsic opportunity of reusability and parameter transfer. This means that, for the same product, the same model and the same model structure can be used over and over again, in different situations for different problems while keeping the attached parameters and the parameter values actually the same. At the same time, this approach ensures that the models built and applied are firmly rooted into the contemporary views and theories of chemistry, biochemistry, physics and physiology as applied in agriculture.

So, it is a logical choice to start this book on food process modelling with an overview of the fundamental techniques of modelling.

In Chapter 1 an overview is given of the powers and pitfalls of deductive modelling based on three examples of processes frequently encountered in our food systems. This chapter describes the problems one encounters in making models useful for practical application, in terms of generic modelling and parameter estimation and parameter transfer.

Chapter 2 devotes its attention to the difficulties and rules of decomposing problems into their constituting processes. In the realm of artificial intelligence,