Food Processing Handbook

Edited by
James G. Brennan

WILEY-VCH
WILEY-VCH Verlag GmbH & Co. KGaA

Food Processing Handbook

Edited by
James G. Brennan

Further of Interest

W. Pietsch

Agglomeration in Industry
Occurrence and Applications

2004
ISBN 3-527-30582-3

K. J. Heller (Ed.)

Genetically Engineered Food
Methods and Detection

2003
ISBN 3-527-30309-X

E. Ziegler, H. Ziegler (Eds.)

Handbook of Flavourings
Production, Composition, Applications, Regulations
Second, Completely Revised Edition

2006
ISBN 3-527-31406-7

J. N. Wintgens (Ed.)

Coffee: Growing, Processing, Sustainable Production
A Guidebook for Growers, Processors, Traders and Researchers

2005
ISBN 3-527-30731-1

G.-W. Oetjen

Freeze-Drying
Second, Completely Revised Edition

2004
ISBN 3-527-30620-X

O.-G. Piringer, A. L. Baner (Eds.)

Plastic Packaging Materials for Food and Pharmaceuticals

2007
ISBN 3-527-31455-5

K. Bauer, D. Garbe, H. Surburg

Common Fragrance and Flavor Materials
Preparation, Properties and Uses
Fourth, Completely Revised Edition

2001
ISBN 3-527-30364-2

F. Müller (Ed.)

Agrochemicals
Composition, Production, Toxicology, Applications

2000
ISBN 3-527-29852-5

Food Processing Handbook

Edited by
James G. Brennan

WILEY-VCH Verlag GmbH & Co. KGaA

Editor

James G. Brennan
16 Benning Way
Wokingham
Berks
RG40 1 XX
UK

Library of Congress Card No.: applied for

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

Bibliographic information published by Die Deutsche Bibliothek
Die Deutsche Bibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data is available in the Internet at <http://dnb.ddb.de>

Typesetting K+V Fotosatz GmbH, Beerfelden
Printing Strauss GmbH, Mörlenbach
Binding Litges & Dopf Buchbinderei GmbH, Heppenheim

Printed in the Federal Republic of Germany

Printed on acid-free paper

ISBN-13: 978-3-527-30719-7
ISBN-10: 3-527-30719-2

Contents

Preface

There are many excellent texts available which cover the fundamentals of food engineering, equipment design, modelling of food processing operations etc. There are also several very good works in food science and technology dealing with the chemical composition, physical properties, nutritional and microbiological status of fresh and processed foods. This work is an attempt to cover the middle ground between these two extremes. The objective is to discuss the technology behind the main methods of food preservation used in today's food industry in terms of the principles involved, the equipment used and the changes in physical, chemical, microbiological and organoleptic properties that occur during processing. In addition to the conventional preservation techniques, new and emerging technologies, such as high pressure processing and the use of pulsed electric field and power ultrasound are discussed. The materials and methods used in the packaging of food, including the relatively new field of active packaging, are covered. Concerns about the safety of processed foods and the impact of processing on the environment are addressed. Process control methods employed in food processing are outlined. Treatments applied to water to be used in food processing and the disposal of wastes from processing operations are described.

Chapter 1 covers the postharvest handling and transport of fresh foods and preparatory operations, such as cleaning, sorting, grading and blanching, applied prior to processing. Chapters 2, 3 and 4 contain up-to-date accounts of heat processing, evaporation, dehydration and freezing techniques used for food preservation. In Chapter 5, the potentially useful, but so far little used process of irradiation is discussed. The relatively new technology of high pressure processing is covered in Chapter 6, while Chapter 7 explains the current status of pulsed electric field, power ultrasound, and other new technologies. Recent developments in baking, extrusion cooking and frying are outlined in Chapter 8. Chapter 9 deals with the materials and methods used for food packaging and active packaging technology, including the use of oxygen, carbon dioxide and ethylene scavengers, preservative releasers and moisture absorbers. In Chapter 10, safety in food processing is discussed and the development, implementation and maintenance of HACCP systems outlined. Chapter 11 covers the various types of control systems applied in food processing. Chapter 12 deals with environmental issues including the impact of packaging wastes and the disposal of refrigerants. In Chapter 13, the various treatments applied to water to be used in food processing are described and the physical, chemical and biological treatments applied to food processing wastes are outlined. To complete the picture, the various separation techniques used in food processing are discussed in Chapter 14 and Chapter 15 covers the conversion operations of mixing, emulsification and size reduction of solids.

The editor wishes to acknowledge the considerable advice and help he received from former colleagues in the School of Food Biosciences, The University of Reading, when working on this project. He also wishes to thank his wife, Anne, for her support and patience.

Reading, August 2005 *James G. Brennan*

List of Contributors

Dr. Araya Ahromrit
Assistant Professor
Department of Food Technology
Khon Kaen University
Khon Kaen 40002
Thailand

Professor Paul Ainsworth
Department of Food and Consumer Technology
Manchester Metropolitan University
Old Hall Lane
Manchester, M14 6HR
UK

Professor Dr. Ing. Ali Abd El-Aal Bakr
Food Science and Technology Department
Faculty of Agriculture
Minufiya University
Shibin El-Kom
A. R. Egypt

Dr. Pedro Bouchon
Departamento de Ingeniera Quimica y Bioprocesos
Pontificia Universidad Católica de Chile
Vicuña Mackenna 4860
Macul
Santiago
Chile

Mr. James G. Brennan (Editor)
16 Benning Way
Wokingham
Berkshire, RG40 1XX
UK

Dr. Brian P. F. Day
Program Leader –
Minimal Processing & Packaging
Food Science Australia
671 Sneydes Road (Private Bag 16)
Werribee
Victoria 3030
Australia

Dr. Bogdan J. Dobraszczyk
School of Food Biosciences
The University of Reading
P.O. Box 226
Whiteknights
Reading, RG6 6AP
UK

Dr. Alistair S. Grandison
School of Food Biosciences
The University of Reading
P.O. Box 226
Whiteknights
Reading, RG6 6AP
UK

Dr. Senol Ibanoglu
Department of Food Engineering
Gaziantep University
Kilis Road
27310 Gaziantep
Turkey

Dr. Ashok Khare
School of Food Biosciences
The University of Reading
P.O. Box 226
Whiteknights
Reading, RG6 6AP
UK

Mr. Craig E. Leadley
Campden & Chorleywood
Food Research Association
Food Manufacturing Technologies
Chipping Campden
Gloucestershire, GL55 6LD
UK

Professor Dave A. Ledward
School of Food Biosciences
The University of Reading
Whiteknights
Reading, RG6 6AP
UK

Dr. Michael J. Lewis
School of Food Biosciences
The University of Reading
P.O. Box 226
Whiteknights
Reading, RG6 6AP
UK

Mrs. Niharika Mishra
School of Food Biosciences
The University of Reading
P.O. Box 226
Whiteknights
Reading, RG6 6AP
UK

Professor Keshavan Niranjan
School of Food Biosciences
The University of Reading
P.O. Box 226
Whiteknights
Reading, RG6 6AP
UK

Dr. Jose Mauricio Pardo
Director
Ingenieria de Produccion
Agroindustrial
Universidad de la Sabana
A.A. 140013
Chia
Columbia

Dr. Margaret F. Patterson
Queen's University, Belfast
Department of Agriculture and Rural
Development
Agriculture and Food Science Center
Newforge Lane
Belfast, BT9 5PX
Northern Ireland
UK

Mr. Nigel Rogers
Avure Technologies AB
Quintusvägen 2
Vasteras, SE 72166
Sweden

Mrs. Carol Anne Wallace
Principal Lecturer
Food Safety Management
Lancashire School of Health
& Postgraduate Medicine
University of Central Lancashire
Preston, PR1 2HE
UK

Mr. R. Andrew Wilbey
School of Food Biosciences
The University of Reading
P.O. Box 226
Whiteknights
Reading, RG6 6AP
UK

Dr. Alan Williams
Senior Technologist & HACCP
Specialist
Department of Food Manufacturing
Technologies
Campden & Chorleywood Food
Research Association Group
Chipping Campden
Gloucestershire, GL55 6LD
UK

1 Postharvest Handling and Preparation of Foods for Processing

Alistair S. Grandison

1.1 Introduction

Food processing is seasonal in nature, both in terms of demand for products and availability of raw materials. Most crops have well established harvest times – for example the sugar beet season lasts for only a few months of the year in the UK, so beet sugar production is confined to the autumn and winter, yet demand for sugar is continuous throughout the year. Even in the case of raw materials which are available throughout the year, such as milk, there are established peaks and troughs in volume of production, as well as variation in chemical composition. Availability may also be determined by less predictable factors, such as weather conditions, which may affect yields, or limit harvesting. In other cases demand is seasonal, for example ice cream or salads are in greater demand in the summer, whereas other foods are traditionally eaten in the winter months, or even at more specific times, such as Christmas or Easter.

In an ideal world, food processors would like a continuous supply of raw materials, whose composition and quality are constant, and whose prices are predictable. Of course this is usually impossible to achieve. In practice, processors contract ahead with growers to synchronise their needs with raw material production. The aim of this chapter is to consider the properties of raw materials in relation to food processing, and to summarise important aspects of handling, transport, storage and preparation of raw materials prior to the range of processing operations described in the remainder of this book. The bulk of the chapter will deal with solid agricultural products including fruits, vegetables, cereals and legumes; although many considerations can also be applied to animal-based materials such as meat, eggs and milk.

1.2 Properties of Raw Food Materials and Their Susceptibility to Deterioration and Damage

The selection of raw materials is a vital consideration to the quality of processed products. The quality of raw materials can rarely be improved during processing and, while sorting and grading operations can aid by removing oversize, undersize or poor quality units, it is vital to procure materials whose properties most closely match the requirements of the process. Quality is a wide-ranging concept and is determined by many factors. It is a composite of those physical and chemical properties of the material which govern its acceptability to the 'user'. The latter may be the final consumer, or more likely in this case, the food processor. Geometric properties, colour, flavour, texture, nutritive value and freedom from defects are the major properties likely to determine quality.

An initial consideration is selection of the most suitable cultivars in the case of plant foods (or breeds in the case of animal products). Other preharvest factors (such as soil conditions, climate and agricultural practices), harvesting methods and postharvest conditions, maturity, storage and postharvest handling also determine quality. These considerations, including seed supply and many aspects of crop production, are frequently controlled by the processor or even the retailer.

The timing and method of harvesting are determinants of product quality. Manual labour is expensive, therefore mechanised harvesting is introduced where possible. Cultivars most suitable for mechanised harvesting should mature evenly producing units of nearly equal size that are resistant to mechanical damage. In some instances, the growth habits of plants, e.g. pea vines, fruit trees, have been developed to meet the needs of mechanical harvesting equipment. Uniform maturity is desirable as the presence of over-mature units is associated with high waste, product damage, and high microbial loads, while under-maturity is associated with poor yield, hard texture and a lack of flavour and colour. For economic reasons, harvesting is almost always a 'once over' exercise, hence it is important that all units reach maturity at the same time. The prediction of maturity is necessary to coordinate harvesting with processors' needs as well as to extend the harvest season. It can be achieved primarily from knowledge of the growth properties of the crop combined with records and experience of local climatic conditions. The 'heat unit system', first described by Seaton [1] for peas and beans, can be applied to give a more accurate estimate of harvest date from sowing date in any year. This system is based on the premise that growth temperature is the overriding determinant of crop growth. A base temperature, below which no growth occurs, is assumed and the mean temperature of each day through the growing period is recorded. By summing the daily mean temperatures minus base temperatures on days where mean temperature exceeds base temperature, the number of 'accumulated heat units' can be calculated. By comparing this with the known growth data for the particular cultivar, an accurate prediction of harvest date can be computed. In addition, by allowing