Chemical and Functional Properties of Food Components Series

Food Flavors

Chemical, Sensory and Technological Properties

EDITED BY

Henryk Jeleń

CRC Press
Taylor & Francis Group

Chemical and Functional Properties
of Food Components Series

Food Flavors

Chemical, Sensory and Technological Properties

EDITED BY

Henryk Jeleń

CRC Press
Taylor & Francis Group
Boca Raton London New York

CRC Press is an imprint of the
Taylor & Francis Group, an **informa** business

CRC Press
Taylor & Francis Group
6000 Broken Sound Parkway NW, Suite 300
Boca Raton, FL 33487-2742

© 2012 by Taylor & Francis Group, LLC
CRC Press is an imprint of Taylor & Francis Group, an Informa business

No claim to original U.S. Government works

Printed in the United States of America on acid-free paper
Version Date: 2011912

International Standard Book Number: 978-1-4398-1491-8 (Hardback)

This book contains information obtained from authentic and highly regarded sources. Reasonable efforts have been made to publish reliable data and information, but the author and publisher cannot assume responsibility for the validity of all materials or the consequences of their use. The authors and publishers have attempted to trace the copyright holders of all material reproduced in this publication and apologize to copyright holders if permission to publish in this form has not been obtained. If any copyright material has not been acknowledged please write and let us know so we may rectify in any future reprint.

Except as permitted under U.S. Copyright Law, no part of this book may be reprinted, reproduced, transmitted, or utilized in any form by any electronic, mechanical, or other means, now known or hereafter invented, including photocopying, microfilming, and recording, or in any information storage or retrieval system, without written permission from the publishers.

For permission to photocopy or use material electronically from this work, please access www.copyright.com (http://www.copyright.com/) or contact the Copyright Clearance Center, Inc. (CCC), 222 Rosewood Drive, Danvers, MA 01923, 978-750-8400. CCC is a not-for-profit organization that provides licenses and registration for a variety of users. For organizations that have been granted a photocopy license by the CCC, a separate system of payment has been arranged.

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

Library of Congress Cataloging-in-Publication Data

Food flavors : chemical, sensory and technological properties / [edited by] Henryk Jelen.
p. cm. -- (Chemical & functional properties of food components)
Includes bibliographical references and index.
ISBN 978-1-4398-1491-8 (hardback)
1. Flavor. 2. Food--Analysis. 3. Food--Composition. 4. Food--Biotechnology. I. Jelen, Henryk.

TX531.F66 2011
664--dc23 2011022870

Visit the Taylor & Francis Web site at
http://www.taylorandfrancis.com

and the CRC Press Web site at
http://www.crcpress.com

Chemical and Functional Properties
of Food Components Series

Food Flavors

Chemical, Sensory and Technological Properties

Chemical and Functional Properties of Food Components Series

SERIES EDITOR
Zdzisław E. Sikorski

Food Flavors: Chemical, Sensory and Technological Properties
Edited by Henryk Jelen

Environmental Effects on Seafood Availability, Safety, and Quality
Edited by E. Grażyna Daczkowska-Kozon and Bonnie Sun Pan

Chemical and Biological Properties of Food Allergens
Edited by Lucjan Jędrychowski and Harry J. Wichers

Food Colorants: Chemical and Functional Properties
Edited by Carmen Socaciu

Mineral Components in Foods
Edited by Piotr Szefer and Jerome O. Nriagu

Chemical and Functional Properties of Food Components, Third Edition
Edited by Zdzisław E. Sikorski

Carcinogenic and Anticarcinogenic Food Components
Edited by Wanda Baer-Dubowska, Agnieszka Bartoszek and Danuta Malejka-Giganti

Methods of Analysis of Food Components and Additives
Edited by Semih Ötleş

Toxins in Food
Edited by Waldemar M. Dąbrowski and Zdzisław E. Sikorski

Chemical and Functional Properties of Food Saccharides
Edited by Piotr Tomasik

Chemical and Functional Properties of Food Lipids
Edited by Zdzisław E. Sikorski and Anna Kolakowska

Chemical and Functional Properties of Food Proteins
Edited by Zdzisław E. Sikorski

此为试读,需要完整PDF请访问: www.ertongbook.com

Preface

Flavor is one of the main food sensory attributes of crucial importance for consumers acceptance of food. Therefore, it attracts the attention of not only food technologists, but also psychologists and neurophysiologists. Flavor compounds are challenging ones to investigate for chemists and biochemists.

This book was intended to provide a concise one volume selection of flavor topics especially important for food technologists and students in food technology/chemistry, who are main target reader groups, and all those who want to have a starting point in a more in-depth exploration of the field of food flavors.

Having this in mind, the book chapters can be grouped into five areas generally focused on the following aspects: *i)* introductory information on flavor compounds and odor and taste perception; *ii)* basics of aroma compounds formation; *iii)* flavor compounds specificity in food technology; *iv)* examples of flavors of selected foods; and *v)* analytical approaches to characterize food flavor compounds.

Chapters 1 and 2 provide an introduction into the chemistry of food odorants and food tastants, whereas Chapter 3 covers the area of flavor perception and provides fundamentals, as well as recent accomplishments in this field. Chapters 4 through 6 are organized based on flavor precursors (lipids, carbohydrates, and aminoacids), presenting universal mechanisms and pathways in aroma compounds biogenesis or formation of process flavors. This gives readers a broad outlook of the common points in the formation of flavors and should help to understand the process of flavor formation in technological processes. Chapter 7 is related to interaction of food matrix with aroma compounds in the process of their binding and release, whereas Chapter 8 describes an significant issue of flavor suppression and enhancement, important especially in functional food production and flavor perception. To guide reader through the legislative meanders of food flavors and flavorings, Chapter 9 provides important data in this respect. Chapters 10 and 11 are also helpful for food technologists, providing information on spices and essential oils, and functional properties of flavor compounds. Chapters 12 through 15 provide insight into various food products and their characteristic aroma. Because of the ample variety of food products with a distinct flavor and, simultaneously, because of the limited space in the book, a choice of products must be a compromise. Cheese flavors, flavor characterization of meat, odorants in wines, and formation of flavor in bread and bakery products represent diversified character of flavor and aroma compounds, their formation, sensory implication, and the roles of microorganisms and technological processes in their formation. Chapter 16 describes the problems of food taints and off-flavors, their origin in foods, and the strategy for their identification. The last part of the book, comprising four chapters, is devoted to analytical aspects. Chapter 17 describes the use of volatile compounds in food authenticity and traceability testing, whereas Chapter 18 presents analytical approach to the determination of key aroma and taste compounds that play a crucial role in formation of food flavor. This chapter links results of instrumental analysis with sensory impressions. Chapter 19 is focused on the techniques used in the sensory characterization of food, whereas Chapter 20 provides the idea, theory, and instrumentation of machine olfaction.

The chapters in this book have been written by specialists from academia and industry based on their teaching and research experience and contain both fundamentals, required to understand basic processes in flavor chemistry/biochemistry and flavor perception and the evaluation of literature to present recent trends in flavor research.

I hope that information provided in the book shall give an outlook of the various aspects of flavor chemistry to the novices in the field, as well as useful information for more experienced readers, and can be a concise starting book for all interested in a role of flavors in food industry.

Editor

Henryk Jeleń received his MS, PhD, and DSc from the Faculty of Food Science and Nutrition, Poznań University of Life Sciences, Poznań, Poland, where he holds a position of professor. He spent his postdoctoral fellowship at the University of Minnesota, worked also as a visiting professor at North Dakota State University, and completed several short term trainings and research assignments at various European universities and institutes. His scientific interests and teaching are focused on food chemistry, mainly flavor chemistry, sample preparation, chromatography and mass spectrometry in food analysis, especially of volatile/flavor compounds. He is a member of the Committee on Food Sciences of the Polish Academy of Sciences, the Chromatography and Related Techniques Commission at the Committee of Analytical Chemistry of the Polish Academy of Sciences, and ACS. He has published nearly 80 journal papers and 8 book chapters.

Contributors

Javaid Aziz Awan
National Institute of Food Science and Technology
University of Agriculture
Faisalabad, Pakistan

Tomas Cajka
Department of Food Chemistry and Analysis
Institute of Chemical Technology
Prague, Czech Republic

Chris R. Calkins
Animal Science Department
University of Nebraska
Lincoln, Nebraska

Corrado Di Natale
Department of Electronic Engineering
University of Rome Tor Vergata
Rome, Italy

Karl-Heinz Engel
Lehrstuhl für Allgemeine Lebensmitteltechnologie
Technische Universität München
Freising, Germany

Vicente Ferreira
Department of Analytical Chemistry
University of Zaragoza
Zaragoza, Spain

Elisabeth Guichard
UMR CSGA (Centre des Sciences du Goût et de l'Alimentation)
INRA (Institut National de Recherche Agronomique)
Dijon, France

Jana Hajslova
Department of Food Chemistry and Analysis
Institute of Chemical Technology
Prague, Czech Republic

Jennie M. Hodgen
Ruminant Technical Services
Intervet/Schering Plough Animal Health
DeSoto, Kansas

Thomas Hofmann
Lehrstuhl für Lebensmittelchemie und molekulare Sensorik
Technische Universität München
Garching, Germany

Thomas Hummel
Department of Otorhinolaryngology
University of Dresden Medical School
Dresden, Germany

Henryk Jeleń
Faculty of Food Science and Nutrition
Poznań University of Life Sciences
Poznań, Poland

Danuta Kalemba
Faculty of Biotechnology and Food Sciences
Institute of General Food Chemistry
Łódź, Poland

Gerhard Krammer
Symrise AG
Global Innovation Flavor & Nutrition
Holzminden, Germany

S. P. D. Lalljie
Unilever Safety and Environment Assurance Center
Bedfordshire, United Kingdom

Jakob Ley
Symrise AG
Global Innovation Flavor & Nutrition
Holzminden, Germany

Manfred Lützow
saqual GmbH
Wettingen, Switzerland

Małgorzata Majcher
Faculty of Food Science and Nutrition
Poznań University of Life Sciences
Poznań, Poland

Katja Obst
Lehrstuhl für Allgemeine Lebensmitteltechnologie
Technische Universität München
Freising, Germany

Salim-ur-Rehman
National Institute of Food Science and Technology
University of Agriculture
Faisalabad, Pakistan

Katharina Reichelt
Symrise AG
Global Innovation Flavor & Nutrition
Holzminden, Germany

Kathy Ridgway
Reading Scientific Services Limited
Berkshire, United Kingdom

Felipe San Juan
Department of Analytical Chemistry
University of Zaragoza
Zaragoza, Spain

Han-Seok Seo
Department of Otorhinolaryngology
University of Dresden Medical School
Dresden, Germany

Peter Schieberle
Lehrstuhl für Lebensmittelchemie
Technische Universität München
Garching, Germany

Takayuki Shibamoto
Department of Environmental Toxicology
University of California–Davis
Davis, California

Henry-Eric Spinnler
UMR de Génie et Microbiologie des Procédés Alimentaires
AgroParisTech/INRA
Thiverval-Grignon, France

Anna Wajs
Faculty of Biotechnology and Food Sciences
Institute of General Food Chemistry
Łódź, Poland

Erwin Wąsowicz
Faculty of Food Science and Nutrition
Poznań University of Life Sciences
Poznań, Poland

Alfreda Wei
Department of Molecular Biosciences
University of California–Davis
Davis, California

Renata Zawirska-Wojtasiak
Faculty of Food Science and Nutrition
Poznań University of Life Sciences
Poznań, Poland

Contents

此为试读，需要完整PDF请访问： www.ertongbook.com

1 Specificity of Food Odorants

Henryk Jeleń

CONTENTS

1.1 INTRODUCTION

Food is one of the main stimuli to our senses in everyday life. Apart from providing nutritious constituents during consumption, food engages the human senses: not only taste and smell, but also sight, hearing, and touch. Sensory properties resulting from the involvement of all senses provide a wholesome picture of food, which is either accepted or rejected by a consumer. Food appearance, texture, and mainly food flavor are the sensory properties that influence food acceptance. Among the sensory properties, flavor is usually the decisive factor for the choice of a particular product.

According to the *New Oxford American Dictionary*, flavor (Brit. *flavour*) is the distinctive quality of a particular food and drink as perceived by the taste buds and the sense of smell. The origin in late Middle English (in the sense fragrance, aroma) is from Old French *flaor*, perhaps based on a blend of Latin flatus "blowing" and foetor "stench." It can be assumed that flavor is the sensation produced by material taken in the mouth perceived principally by the senses of taste and smell, and also by the general pain, tactile, and temperature receptors in the mouth.

Food flavor is of cardinal importance not only for consumers at the moment of choosing a particular product, but also an important feature for breeders of fruit and vegetable varieties and in selection of raw materials used for food production. Flavor is an issue for food technologists, when developing new products, meeting consumers' requirements, and controlling it during processing and storage. Finally, flavor is one of the main factors that determine the shelf life of a particular food product. Development of off-flavors as a result of enzymatic, chemical, or microbial changes can make food products unpalatable. Therefore, maintaining the proper flavor of food products is in the interest of both consumers and producers.

1.2 FOOD VOLATILES AND FOOD ODORANTS

Odorants have to be volatile to reach the human olfactory system; therefore, it is accepted that, generally, odorants are molecules characterized by relatively high vapor pressures of molecular weight lower than 300 Da, although there are odorants that are relatively nonvolatile [5α-androst-16-en-3-one—mammalian pheromone having sweaty, ruinous, unpleasant woody odor; odor threshold (OT) = 0.00062 mg/kg; vapor pressure = 4.22×10^{-3}]. The vapor pressure of odorants can vary over several orders of magnitude. Majority of volatiles are also relatively nonpolar (hydrophobic) compounds, which favors their partition in aqueous media.

A differentiation should be made between volatile and odoriferous compounds. More than 11000 volatile compounds have been identified in food. They have been compiled as a database accessible on the Internet (VCF Volatile Compounds in Foods, 2010, www.vcf-online.nl) and fill 18 different chemical classes (hydrocarbons, aldehydes, ketones, esters, acids, lactones, halogens, sulfur compounds, etc.). However, it is estimated that only 5%–10% of them play a significant role in the formation of specific aromas of food products. The importance of particular compounds in flavor formation is related to their concentration and their odor thresholds. Volatile compounds influence the odor of a particular food when present in concentrations higher than their odor threshold, or they can also influence the flavor when present in mixtures that exceed these odor thresholds as a result of additive or synergistic effects.

Increasing the potential of separation techniques, and developments in gas chromatography especially comprehensive gas chromatography (GC × GC) allow the detection of hundreds or even thousands of peaks. Therefore, among the bulk of volatile compounds, key odorants of a product are of special importance in flavor analysis. As a consequence, although profiles of volatile compounds are useful in metabolomic or authenticity/traceability testing (Chapter 17), the analysis of food aroma compounds should be sensory guided. In analysis of food odorants, gas chromatography-olfactometry (GC-O) allows selection of aroma important compounds from numerous volatiles (van Ruth 2001). This approach to the analysis of food odorants and tastants is discussed in detail in Chapter 18.

1.3 ODOR THRESHOLDS AND AROMA DESCRIPTION

Odoriferous compounds are present in food in very low concentrations, usually in milligram per kilogram amounts, but very often in much lower concentrations—microgram per kilogram or even nanogram per kilogram of the product. Our olfactory system is able to detect some odorants present in extremely low concentrations. Odoriferous molecules are sensed by the olfactory epithelium located in the nasal cavity, which can be reached entering a nasal passage via the nose (orthonasal) or via the mouth (retronasal path). In humans, introduction of an odorant above a certain threshold into the nasal cavity triggers a response to the stimulus (see Chapter 3). Odor threshold can be defined as the lowest concentration of a compound in a specified medium that is sufficient for the recognition of a particular odor. In flavor description, two thresholds are used: detection threshold defined as the lowest physical intensity at which a stimulus is perceptible, and the recognition threshold (odor threshold), which is the lowest intensity in which the stimulus can be correctly defined or identified.

To characterize aroma compounds and their contribution to food flavor, odor thresholds need to be determined. Traditionally, this has been carried out in air using olfactometers; however, for food products, a more reasonable solution is to determine odor thresholds in water (Buttery 1999). This is based on the assumption that in determining a water threshold, the odor threshold of a compound in air, where the compound is at equilibrium between the water solution and air, is determined (Buttery et al. 1973). Odor threshold in air (T_a) can be determined from the following equation:

$$T_a = T_w \times K_{aw}$$

where T_w is a threshold concentration in water and K_{aw} is the air-to-water partition of the compound at the testing temperature. Similarly, threshold in oil can be calculated as follows:

$$T_{ol} = T_w \times (K_{aw}/K_{aol})$$

where K_{aw}/K_{aol} is equal to the oil-to-water partition.

To quantify the influence of a particular odor compound on the aroma of a product, aroma values (AV) are calculated by integrating the concentration of a particular compound and its odor threshold—AV is the ratio of a compound's concentration to its odor threshold (Rothe and Thomas 1963). An example of such approach is shown in Table 1.1. Furthermore, the log of concentration/threshold ratios is used to express the contribution of a compound to a product's overall aroma.

Basic tastes can be relatively easily described (sweet, salty, sour, bitter, and with umami being classified as the fifth basic taste). Contrary to this, description of odors is often extremely difficult to do in unequivocal terms. Complex mixtures are difficult to describe unless there is one dominant compound that influences flavor. Odors are described using adjectives comparing odors with known products/impressions (e.g., hay-like, fruity). Many terms describing odors include animal (musk, civet), camphoraceous, citrus, earthy, fatty, floral, green, herbaceous, medicinal, resinous, spicy, waxy, or woody. For complicated (from a flavor point of view) products, such as whisky, wine, or beer, flavor wheels have been constructed to help in describing main and additional odors and notes associated with a product (Figure 1.1).

1.4 CHEMICAL PROPERTIES AND PERCEPTION OF ODORANTS

Perception of food odorants is related to the nature of food product from which an aroma compound is released (food matrix) and the chemical/spatial nature of

TABLE 1.1
Aroma Compounds in Rye Bread Crust

Compound	Concentration (ppm)	Aroma Value[a]
Ethanol	1100	110
Acetaldehyde	23	25
Acetoin	1	1
Diacetyl	1.3	330
2/3-Methylbutanal	15	1900
Pyruvic aldehyde	9	20
2-Methylpropanal	6	6000
Furfural	19	300

Source: Rothe, M., and Kruse, H.-P., in *Flavor Chemistry. Thirty Years of Progress*, ed. R. Teranishi, E.L. Wick, and I. Horstein, 367–375, Kluwer Academic/Plenum Publishers, New York, 1999. With permission.

[a] Concentration (ppm)/threshold in water (ppm).

the odorant molecule. Aroma compounds interact with food macro constituents—proteins, lipids, and carbohydrates. The interactions influence release of aroma compounds from the matrix, resulting in partition coefficients that in consequence influence the levels of aroma compounds in the headspace. Odor threshold values of 2,4,6-trichloroanisol vary substantially in matrices of different viscosity and composition: in water, it is estimated at 7.6×10^{-8}; in beer, 7×10^{-6}; in edible oil, 7×10^{-3}; and in egg yolk, 2.4×10^{-3} (Maarse et al. 1987).

The food macroconstituents can govern aroma binding and release in various ways: the presence of polysaccharides can alter partition of volatiles due to modified viscosity or formation of inclusion complexes. Binding of flavor compounds to proteins is dependent on protein type. The nature of aroma binding to protein molecules can be reversible, based on hydrogen bonding and hydrophobic interactions, or can be irreversible, such as in the case of sulfur compounds reacting with proteins. Lipids influence partition of volatile compounds in foods to a great extent. In emulsions, even a low level of fat can substantially influence absorption of volatiles (Roberts and Pollien 2000). The process of aroma release was discussed in detail in several review papers (Druaux and Voilley 1997; Guichard 2002). The problem is of high importance for food manufacturers especially considering the trends for production of fat-free or low-fat products. Binding and release of aroma compounds are discussed in detail in Chapter 7.

The chemical nature of odorants influences the way they are perceived. Functional groups position influences odor threshold. As an example, isomers of trichloroanisole—2,4,6-trichloroanisole and 2,3,6-trichloroanisole can be cited having odor thresholds of 0.03 and 0.0003 ppb, respectively (Maarse et al. 1987). Size and character of the functional groups may also influence odor thresholds via the influence of

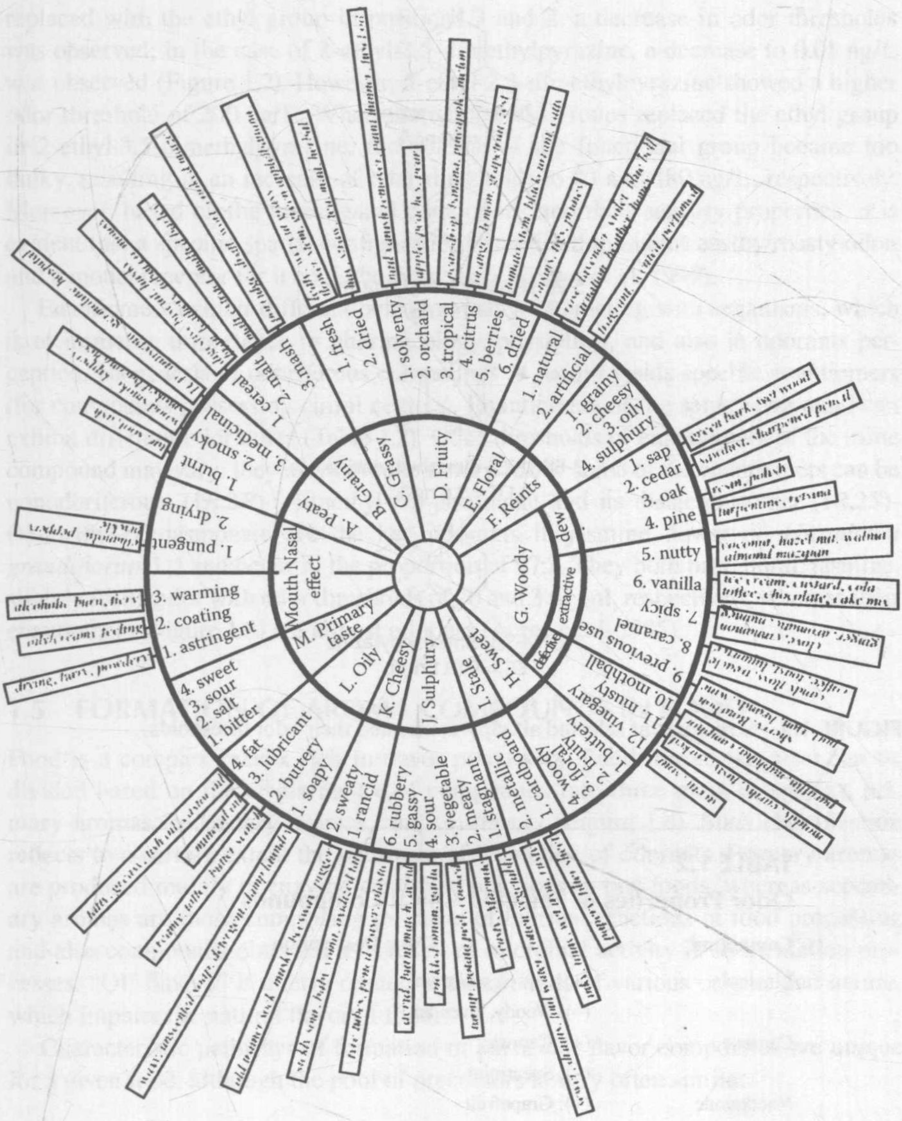

FIGURE 1.1 Whisky flavor wheel. (From Lee, K.-Y.M., Paterson, A., Piggot, J.R., *J. Inst. Brewing* 107, 287–313, 2001. With permission.)

odorant receptor spatial interaction. A good example showing the influence of functional groups on odor thresholds are alkylpyrazines. Werner and coworkers studied the structure–odor activity relationships of 80 alkylpyrazines. Tetramethylpyrazine had an odor threshold of >2000 ng/L, whereas trimethylpyrazine had a substantially lower odor threshold of 50 ng/L (in air). When one of the methyl groups was

此为试读，需要完整PDF请访问： www.ertongbook.com