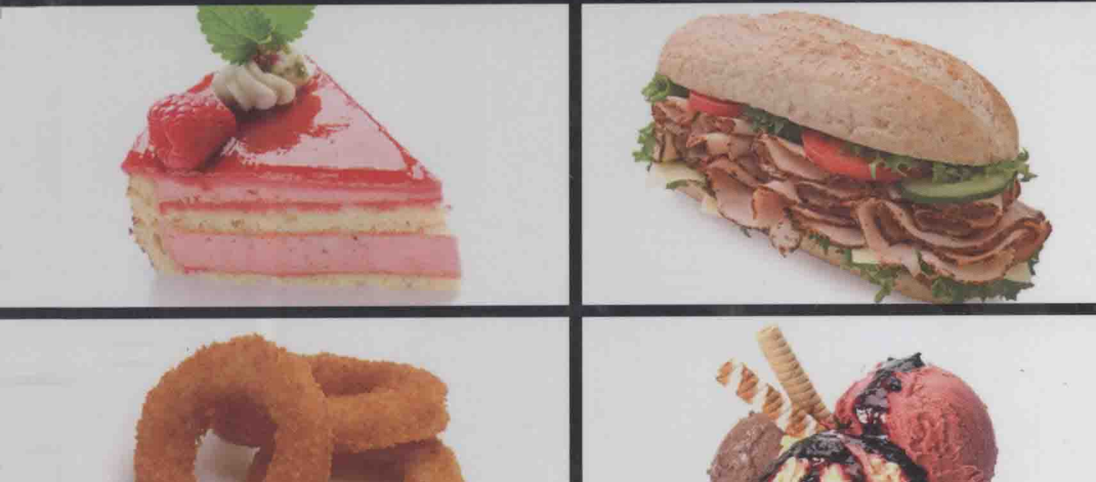
Hydrocolloids in Food Processing



EDITOR

Thomas R. Laaman

WILEY-BLACKWELL

IFT PRESS

Hydrocolloids in Food Processing

Editor

Thomas R. Laaman

WILEY-BLACKWELL
A John Wiley & Sons, Ltd., Publication

IFT
PRESS

Edition first published 2011
© 2011 Blackwell Publishing, Ltd. and Institute of Food Technologists

Blackwell Publishing was acquired by John Wiley & Sons in February 2007. Blackwell's publishing program has been merged with Wiley's global Scientific, Technical, and Medical business to form Wiley-Blackwell.

Editorial Office
2121 State Avenue, Ames, Iowa 50014-8300, USA

For details of our global editorial offices, for customer services, and for information about how to apply for permission to reuse the copyright material in this book, please see our Website at www.wiley.com/wiley-blackwell.

Authorization to photocopy items for internal or personal use, or the internal or personal use of specific clients, is granted by Blackwell Publishing, provided that the base fee is paid directly to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923. For those organizations that have been granted a photocopy license by CCC, a separate system of payments has been arranged. The fee code for users of the Transactional Reporting Service is ISBN-13: 978-0-8138-2076-7/2011.

Designations used by companies to distinguish their products are often claimed as trademarks. All brand names and product names used in this book are trade names, service marks, trademarks or registered trademarks of their respective owners. The publisher is not associated with any product or vendor mentioned in this book. This publication is designed to provide accurate and authoritative information in regard to the subject matter covered. It is sold on the understanding that the publisher is not engaged in rendering professional services. If professional advice or other expert assistance is required, the services of a competent professional should be sought.

Library of Congress Cataloging-in-Publication Data

Hydrocolloids in food processing / edited by Thomas R. Laaman.
p. cm. – (IFT Press series)
Includes bibliographical references and index.
ISBN 978-0-8138-2076-7 (hardback : alk. paper)
1. Hydrocolloids. I. Laaman, Thomas.
TP456.H93H93 2010
664–dc22 2010011387

A catalog record for this book is available from the U.S. Library of Congress.

Set in 11.5/13.5 Times NR PS by Aptara® Inc., New Delhi, India
Printed in Singapore by Markono Print Media Pte Ltd

Disclaimer
The publisher and the author make no representations or warranties with respect to the accuracy or completeness of the contents of this work and specifically disclaim all warranties, including without limitation warranties of fitness for a particular purpose. No warranty may be created or extended by sales or promotional materials. The advice and strategies contained herein may not be suitable for every situation. This work is sold with the understanding that the publisher is not engaged in rendering legal, accounting, or other professional services. If professional assistance is required, the services of a competent professional person should be sought. Neither the publisher nor the author shall be liable for damages arising herefrom. The fact that an organization or Website is referred to in this work as a citation and/or a potential source of further information does not mean that the author or the publisher endorses the information the organization or Website may provide or recommendations it may make. Further, readers should be aware that Internet Websites listed in this work may have changed or disappeared between when this work was written and when it is read.

1 2011

Hydrocolloids in Food Processing

IFT PRESS

The *IFT Press* series reflects the mission of the Institute of Food Technologists – to advance the science of food contributing to healthier people everywhere. Developed in partnership with Wiley-Blackwell, *IFT Press* books serve as leading-edge handbooks for industrial application and reference and as essential texts for academic programs. Crafted through rigorous peer review and meticulous research, *IFT Press* publications represent the latest, most significant resources available to food scientists and related agriculture professionals worldwide.

Founded in 1939, the Institute of Food Technologists is a nonprofit scientific society with 22,000 individual members working in food science, food technology, and related professions in industry, academia, and government. IFT serves as a conduit for multidisciplinary science thought leadership, championing the use of sound science across the food value chain through knowledge sharing, education, and advocacy.

IFT Book Communications Committee

IFT Press Editorial Advisory Board

WILEY-BLACKWELL
A John Wiley & Sons, Ltd., Publication

Titles in the *IFT Press* series

- *Accelerating New Food Product Design and Development* (Jacqueline H. Beckley, Elizabeth J. Topp, M. Michele Foley, J.C. Huang and Witoon Prinyawiwatkul)
- *Advances in Dairy Ingredients* (Geoffrey W. Smithers and Mary Ann Augustin)
- *Bioactive Proteins and Peptides as Functional Foods and Nutraceuticals* (Yoshinori Mine, Eunice Li-Chan and Bo Jiang)
- *Biofilms in the Food Environment* (Hans P. Blaschek, Hua H. Wang, and Meredith E. Agle)
- *Calorimetry and Food Process Design* (Gönül Kaletunç)
- *Food Ingredients for the Global Market* (Yao-Wen Huang and Claire L. Kruger)
- *Food Irradiation Research and Technology* (Christopher H. Sommers and Xuetong Fan)
- *Foodborne Pathogens in the Food Processing Environment: Sources, Detection and Control* (Sadhana Ravishankar, Vijay K. Juneja and Divya Jaroni)
- *High Pressure Processing of Foods* (Christopher J. Doona and Florence E. Feeherry)
- *Improving Import Food Safety* (Wayne C. Ellefson, Lorna Zach and Darryl Sullivan)
- *Microbial Safety of Fresh Produce: Challenges, Perspectives and Strategies* (Xuetong Fan, Brendan A. Niemira, Christopher J. Doona, Florence E. Feeherry and Robert B. Gravani)
- *Microbiology and Technology of Fermented Foods* (Robert W. Hutkins)
- *Multiphysics Simulation of Emerging Food Processing Technologies* (Kai Knoerzer, Pablo Juliano, Peter Roupas and Cornelis Versteeg)
- *Multivariate and Probabilistic Analyses of Sensory Science Problems* (Jean-François Meullenet, Rui Xiong, and Christopher J. Findlay
- *Nanoscience and Nanotechnology in Food Systems* (Hongda Chen)
- *Natural Food Flavors and Colorants* (Mathew Attokaran)
- *Nondestructive Testing of Food Quality* (Joseph Irudayaraj and Christoph Reh)
- *Nondigestible Carbohydrates and Digestive Health* (Teresa M. Paeschke and William R. Aimutis)
- *Nonthermal Processing Technologies for Food* (Howard Q. Zhang, Gustavo V. Barbosa-Cànovas, V.M. Balasubramaniam, Editors; C. Patrick Dunne, Daniel F. Farkas, James T.C. Yuan, Associate Editors)
- *Nutraceuticals, Glycemic Health and Type 2 Diabetes* (Vijai K. Pasupuleti and James W. Anderson)
- *Organic Meat Production and Processing* (Steven C. Ricke, Michael G. Johnson and Corliss A. O'Bryan)
- *Packaging for Nonthermal Processing of Food* (J. H. Han)
- *Preharvest and Postharvest Food Safety: Contemporary Issues and Future Directions* (Ross C. Beier, Suresh D. Pillai, and Timothy D. Phillips, Editors; Richard L. Ziprin, Associate Editor)
- *Processing and Nutrition of Fats and Oils* (Ernesto M. Hernandez, and Afaf Kamal-Eldin)
- *Processing Organic Foods for the Global Market* (Gwendolyn V. Wyard, Anne Plotto, Jessica Walden and Kathryn Schuett)
- *Regulation of Functional Foods and Nutraceuticals: A Global Perspective* (Clare M. Hasler)
- *Resistant Starch: Sources, Applications and Health Benefits* (Yong-Cheng Shi and Clodualdo Maningat)
- *Sensory and Consumer Research in Food Product Design and Development* (Howard R. Moskowitz, Jacqueline H. Beckley, and Anna V.A. Resurreccion)
- *Sustainability in the Food Industry* (Cheryl J. Baldwin)
- *Thermal Processing of Foods: Control and Automation* (K. P. Sandeep)
- *Trait-Modified Oils in Foods* (Frank T. Orthoefer and Gary R. List)
- *Water Activity in Foods: Fundamentals and Applications* (Gustavo V. Barbosa-Cànovas, Anthony J. Fontana Jr., Shelly J. Schmidt, and Theodore P. Labuza)
- *Whey Processing, Functionality and Health Benefits* (Charles I. Onwulata and Peter J. Huth)

Preface

This is a highly practical book written primarily for three groups who make their living in the food industry: product development scientists, quality assurance scientists, and purchasing directors and managers. University professors who want to impart industry-based practical knowledge to their students and food science students, especially those in product development courses can also richly benefit from this work. For students, the chapters of this book can provide valuable insights into the results of decades long practical research in developing food products utilizing hydrocolloids as key components.

Although most of the writers of this book have Ph.D. degrees, and nearly all of the rest have M.S. degrees, these writers also have decades of lab, pilot plant, and plant experience in this field. They have combined a thorough scientific education with the practical hands on experience required to master this difficult area of practical hydrocolloid applications. These writers were all chosen because they are the *practical* masters in hydrocolloid knowledge in their specific food areas.

How should this book be read? Carefully, thoughtfully, and repetitively. Practical hydrocolloid applications can be mastered and once mastered, provide one of the most valuable job skills in this business. So many foods depend on thorough mastery of the hydrocolloid component and once that is accomplished, the rest of the food product usually just falls together, literally. Of course there are other specialized knowledge areas that are important to many foods, such as flavor chemistry, but hydrocolloids even impact flavor quite noticeably. In any case, mastery in this field usually requires many reviews of the same information, until it becomes second nature.

Thus, it is recommended that this book be kept in the lab or office, and read over and over again until it becomes thoroughly familiar. Also, regardless of the food area that one is employed in, reading all the chapters in the book will pay good dividends. Each chapter provides valuable insights into various hydrocolloids and these insights extend well beyond the specific food applications being discussed. Also, much of the innovativeness in our food industry results from applying concepts used in one branch of the food industry to another branch of industry. Finally, it is good to become familiar with other branches of the food industry because one may be employed there in the future; few jobs are all that stable in this industry.

Some authors of chapters in this book have referenced many other sources, some only a few or none. Why is that? The truth of the matter is much of the key practical knowledge in the hydrocolloid area is proprietary. Those authors who are employed by various hydrocolloid suppliers have the approval of their individual company to publish the material in their chapters that may belong to that company. But even in those cases some or much of the material in their chapters may be knowledge they may have picked up in various research assignments they have had over the course of their careers, in many companies, or as consultants.

It would be difficult in most cases to reference manuals published by companies in the hydrocolloid field since the material is so totally hackneyed. Six different companies that sell a certain hydrocolloid have almost the identical information in their brochures and that same material was already found in publications from 30 years ago of companies that no longer exist. In any case, much material in this book is new and has never appeared in print before in any company brochure.

There can be several hydrocolloid combinations that will make quality, stable food products. Most of the chapter authors try to provide some of these alternate approaches. In cases where one combination is suggested there may be other combinations that will also work. In those cases gaining expertise in how and why one hydrocolloid combination is particularly effective can stimulate the reader to consider other approaches as well. That is all part of hydrocolloid learning and mastery. I would expect that some of the more creative readers of this book will find new approaches to their specific product development challenges based on the foundations laid in this volume.

This book is divided into three sections. The first chapter provides important general practical concepts in the use of hydrocolloids that are applicable to many food products. Chapters 2–9 provide food-by-food specific details in the utilization of hydrocolloids in these various categories. In most cases, the chapters explain not only how to successfully use hydrocolloids but most of the keys toward making those food categories themselves. Thus, the chapters are actually practical guides to making specific foods. Chapters 10 and 11 provide a thorough guide to purchasing hydrocolloids, and contain valuable information for purchasing directors, QA scientists, and product development specialists.

It is hoped that this book not only helps significantly in practical ways in your current and future jobs, but that you begin to glimpse the love and fascination the complex world of hydrocolloids brings to us who have labored for so long in this viscous realm.

Thomas R. Laaman
Guaranteed Gums

Contributor List

Maureen Akins (Chapter 5)
TIC Gums Inc.
White Marsh, MD, USA

Ian Challen (Chapter 8)
Hydrocolloid Solutions
Houston, TX, USA

William Santa Cruz (Chapter 4)
Gums Per
Tucson, AZ, USA

Milda E. Embuscado (Chapter 9)
McCormick & Co. Inc.
Hunt Valley, MD, USA

Alan H. King (Chapter 2)
Rutgers, The State University of New Jersey
Westfield, NJ, USA

Joseph Klemaszewski (Chapter 7)
Cargill Inc.
Atlanta, GA, USA

Thomas R. Laaman (Chapters 1, 6, 10, 11)
Guaranteed Gums
Madbury, NH, USA

James W. Lamkey (Chapter 3)
Symrise
Teterboro, NJ, USA

Ralph Moorhouse (Chapter 8)
Hydrocolloid Solutions
Houston, TX, USA

Marceliano B. Nieto (Chapter 5)
TIC Gums Inc.
Abingdon, MD, USA

Philip A. Rakes (Chapter 6)
Main Street Ingredients
La Crosse, WI, USA

Table of Contents

Chapter 1

Hydrocolloids: Fifteen Practical Tips

Thomas R. Laaman

Tip One: Dissolving Hydrocolloids—The Influence of Mesh Size

Achieving maximum hydrocolloid functionality in most food products begins with fully dissolving the hydrocolloid. Particle size or mesh size is a fundamental issue influencing solubility. The basic principle is that larger particles, corresponding to a coarser mesh size, such as 40–80 mesh, take longer to dissolve because the water takes longer to penetrate the dry hydrocolloid particle. A finer mesh particle, such as those that pass through 120, 150, or 200 mesh screens, takes less time for water to penetrate and become fully soluble.

However, the converse of this situation is that a coarser size particle is less subject to lumping, while a finer mesh particle lumps more easily. Once lumps are formed, achieving full solubility becomes more difficult and also takes much more mixing to do so.

There are two ways to overcome the potential for lumping for small particle size hydrocolloids. One is to use high agitation mixing. The other is to preblend the hydrocolloid with another dry ingredient such as sugar. By preblending, the hydrocolloid particles are separated from each other before entering the liquid, thereby minimizing lumping.

In summary, if high agitation is used in dispersing the hydrocolloid or if it can be preblended with a dry ingredient then fine mesh grades will allow the most rapid solubility. If mixing is not as vigorous and

Hydrocolloids in Food Processing, Thomas R. Laaman

the hydrocolloid is not preblended then it is safer to use a coarser mesh product to avoid lumping, even though this will require more mixing time to achieve full solubility.

Tip Two: Dissolving Hydrocolloids—The Influence of Temperature

Some hydrocolloids require heat to dissolve. In these cases, it is important to know exactly how much temperature is required for the exact grade being used. There can be a substantial difference in the required temperature based on other ingredients, especially ions. Thus, it is important to heat the food product to different temperatures and determine the minimum temperature to achieve full functionality, in terms of maximum viscosity, gel strength, or stability of the food product.

Temperature should be measured carefully. First, the thermometer or thermal probe being used must be precise and accurate. Mechanical thermometers are especially notorious for requiring frequent calibration to ensure accuracy. Another issue can be that the product mixing is not sufficiently vigorous during heating, allowing pockets of higher or lower temperature. This must be ascertained by moving the thermometer or thermal probe around to different locations in the mix to determine if temperature gradients exist. The minimum temperature achieved in any part of the mix should be the benchmark used to determine if the temperature is adequate.

One contrary thought is important to add. Although it is important to achieve full functionality of a hydrocolloid, it is also true that some hydrocolloids can be partially degraded by excessive heat, for example, guar gum. Some other hydrocolloids may be degraded if there is a combination of heat and acid, for example, carrageenan. Therefore, the heating should be adequate to fully dissolve all the hydrocolloids and thus gain full viscosity, but not high enough that the viscosity is decreased due to partial hydrolysis of the hydrocolloid.

Tip Three: Dissolving Hydrocolloids—The Influence of Cations

Some hydrocolloids are not highly influenced by ions (except at very high ion concentrations), for example, agar, xanthan gum, guar gum, and locust bean gum. Several others are influenced in their solubilization by ions. These include sodium alginate, carrageenan, pectin, gellan gum, and sodium carboxymethyl cellulose (CMC). In these cases divalent cations and in some cases monovalent cations can influence the ability of the hydrocolloid to dissolve.

Calcium is the major issue for sodium alginate, ι-carrageenan, low-methoxy pectin, and gellan gum. Potassium is the major issue for κ-carrageenan, and sodium chloride can inhibit full viscosity development for CMC for certain grades. Options to circumvent reduced solubility include the following procedures.

First, the ions can be added to the food product after the hydrocolloid has been dissolved. Second, for gums such as carrageenan, where the ions are present with the gum powder, solubility can be achieved by heating to a higher temperature.

Third, for calcium, sequestrants can be added to bind these ions, at least temporarily, to allow the gum to dissolve. If water used in the processing plants is naturally quite high in calcium, this approach may be necessary if the water is not pretreated to remove these ions. Sequestrants include phosphate compounds such as sodium hexametaphosphate, tetrasodium pyrophosphate, and dipotassium phosphate and also citrates.

Fourth, also for calcium, it is possible to add in very low solubility forms, thus largely delaying the calcium going into solution until after the gum has dissolved. Tricalcium phosphate is a very slow-dissolving calcium source, and dicalcium phosphate is also quite slow, the anhydrous form being slower than the dihydrate form.

Tip Four: Gelling Hydrocolloids—The Effect of Temperature

Some hydrocolloids gel by simply cooling a hot solution. Agar and gelatin are the prime examples. Others gel after cooling, but also require ions to be present. These include κ- and ι-carrageenan, low-methoxy pectin, and gellan gum. High-methoxy pectin gels after cooling in a low-pH or high-sugar environment. Methyl cellulose forms and maintains a gel only while it is being heated.

The first significant aspect is to make sure the gum has been given enough heat to fully dissolve, as discussed in Tip two. Whatever amount of gum is left undissolved will not contribute to the final gel properties. Only fully dissolved gum will gel when cooled. The exact gelling temperature will vary by the product and grade in a similar fashion as the solubility temperature varies. But this is generally less significant since eventually the product will generally be cooled to at least room temperature and fully gel.

The key item to remember when gel formation is occurring during cooling is whether the gel will be broken apart during gel formation or left intact. ι-Carrageenan has some gel "healing" properties, but most gums will not reform a gel well when the gel is broken up by agitation or motion during gelling. For most products, it is imperative that the gelled product is placed into a quiescent situation when the critical gelling temperature is near to being reached. For products where a disrupted gel is sought, it is still important to make sure that disruption occurs in a way to facilitate the exact product texture desired. This may require some experimentation.

There are cases where a semi-gelled structure is sought and in those cases mixing during cooling is often acceptable. One interesting example is the use of κ-carrageenan to suspend cocoa powder and also provide some mouthfeel in chocolate milk. If there is no mixing during the gel formation stage, the cocoa powder will completely settle out. If the product is mixed during cooling, the κ-carrageenan will be able to begin to suspend the cocoa as its weak gel begins to form. In this case the disruption of the gel by mixing is not a negative since the texture and stabilizing functionality that is desired is achieved.

Tip Five: Gelling Hydrocolloids—The Influence of Cations

Cations are needed for gelation of many hydrocolloids. Those requiring heating and cooling simply need adequate amounts of the appropriate cation to fully gel. Some cations may be present in the hydrocolloid powder, some in the other ingredients used to make the food, and some may be added to ensure that an adequate amount is present. Generally, enough should be added to get maximum gel strength, especially if it is a gelled product. If the gel is too strong then it is more economical to reduce the amount of the hydrocolloid used than to have the hydrocolloid starved for gelling ions.

An exception to this principle is when a semi-gelled-type product is sought. This type of product would generally be not seen as a fully gelled product but as something pourable, such as a sauce. However, some