
Agro-Processing and Food Engineering

Harish Kumar Sharma • Navneet Kumar
Editors

Agro-Processing and Food Engineering

Operational and Application Aspects

 Springer

Editors

Harish Kumar Sharma
National Institute of Technology (NIT),
(An Institute of National Importance)
Agartala, Tripura, India

Navneet Kumar
Department of Processing and Food Engineering
College of Agricultural Engineering and
Technology, Anand Agricultural University
Godhra, Gujarat, India

ISBN 978-981-16-7288-0

ISBN 978-981-16-7289-7 (eBook)

<https://doi.org/10.1007/978-981-16-7289-7>

© The Editor(s) (if applicable) and The Author(s), under exclusive license to Springer Nature Singapore Pte Ltd. 2022

This work is subject to copyright. All rights are solely and exclusively licensed by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.

The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

*Dedicated
to
the Almighty
and
Mrs. Meenu Sharma and Mrs. Shilpi Goyal*

Preface

Agricultural production is on a rising trend across the globe, which is putting pressure on agro-processing industries to timely handle the produce and keep it safe for a longer duration. The agro-processing industries deal with various unit operations from receiving harvested crop to the finished product. The textbook entitled *Agro-Processing and Food Engineering: Operational and Application Aspects* has been conceptualized with a view to cover the most relevant topics in the area for graduating students. In the book, simple illustrations are used in every chapter for easier understanding of the involved fundamentals, concepts, and processes. A number of solved examples are also included in different chapters to provide emphasis on problem solving. Efforts are made to simplify technological aspects, mathematical derivations, etc. to the maximum extent so that young minds could easily understand. Similar approaches are adopted in solved examples, so that concepts can be better understood by students/academicians. Several unsolved questions are also provided at the end of every chapter to review the progress made by students/readers.

The text in the book starts from presenting a comprehensive production status of different popular agricultural commodities. Further, the engineering properties of food materials are presented. The knowledge of the properties remains essential in clearing the understanding with respect to design, operation, and control of various processing equipment and quality of finished products. Material handling systems are used in agro-processing industry to increase the level of mechanization, which improves the consistency and quality of the produce, and therefore the knowledge with respect to designing of efficient material handling system becomes very important to students. The moisture content of the agro-produce, which can be optimally retained through drying/dehydration in cereals, pulses, and oilseeds, assures safer storage for longer duration. The desired size of agro-produce can be achieved by different milling equipment to obtain the material in the form of flour, powder, etc.

The effective mixing is an important unit operation to cater to the need of nutritious substitutes of existing food items and to create uniformity and homogeneity during the operation. The cleaning of grains is performed before other unit operations, and grading of the finished product can be achieved using different graders/separators to control the quality. The storage life of the foods can be enhanced by using various traditional and modern storage structures. The processing

can add value; therefore, processing of cereals, fruits and vegetables, oilseeds, and pulses is covered and presented in such a way that the concepts and technological aspects are easier to understand and beneficial to students and the scientific fraternity. The technical manpower involved in various capacities in agro-industries can also get first-hand knowledge through the technological concepts and mechanisms covered in the book.

All the chapters have been written by Teachers/Researchers, working in the field; therefore, the concepts are made simpler and easier to understand. Efforts are made to simplify every aspect; therefore, this handbook is expected to be unique for students. However, feedback in any form from any corner shall be encouraged to further strengthen the quality of the book in the time to come. Since the idea for conceptualization of the book emerged out of the need of students on the various topics covered in this book therefore it is anticipated that this book will cater to the need of students, technicians, academicians, and researchers working in the area of Agro-processing, Food Engineering, Agricultural Process Engineering, Food Technology, and allied fields.

Agartala, Tripura, India
Godhra, Gujarat, India

Harish Kumar Sharma
Navneet Kumar

Acknowledgments

The book was conceptualized 3 years before and is now presented in this form. For this accomplished task, firstly, we wish to acknowledge the contributions of several persons over the years for providing assistance in writing, organizing, and editing. The editors would like to thank all the researchers of the globe for their meaningful contribution and their findings, which helped us to understand and bring out this manuscript for the scientific society.

We also like to extend our heartfelt thanks to the equipment manufacturers, Food and Agriculture Organization of the United Nations, Bureau of Indian Standards, Food Safety and Standards Authority of India, and other organizations and resources, which had provided assistance in the compilation and interpretation of different concepts using the data.

The editors also express their gratitude to the parent organizations National Institute of Technology, Agartala, India, Sant Longowal Institute of Engineering and Technology, Longowal, Punjab, India, and College of Agricultural Engineering and Technology, Anand Agricultural University, Godhra, Gujarat, India, for providing the opportunity to interact with the students during deliberation of lectures on similar subjects.

Thanks are also due to all our coauthors from various reputed organizations for writing the chapters and complying to critical comments within the given time frame. We also express our sincere thanks to Dr. Naren Aggarwal, Dr. Mei Hann Lee, and Vaishnavi Venkatesh from Springer for helping us throughout the publication process.

We greatly acknowledge the help of all the people including Unknown Reviewers and our beloved Teachers, who helped us directly and indirectly during the course of writing this manuscript. The natural support was unprecedented from all the directions.

Last but not least, our special thanks are due to our family members, especially Manishi, Kshitiz, and Kushagra, for their active contribution, constructive support, encouragement, and patience during the writing and editing work over the last several months.

Harish Kumar Sharma
Navneet Kumar

Contents

1	Agro Processing: Scope and Importance	1
	Harish Kumar Sharma and Navneet Kumar	
2	Engineering Properties of Foods	23
	Vivek Kumar, Harish Kumar Sharma, and Navneet Kumar	
3	Material Handling and Transportation Devices	81
	Ajay Patel, Shubhangi Thakre, Nilesh B. Kardile, and Rachna Sehwat	
4	Design of Material Handling Systems	111
	Navneet Kumar and Harish Kumar Sharma	
5	Drying	147
	Navneet Kumar and Harish Kumar Sharma	
6	Size Reduction	217
	Yogesh Kumar, Vijay Singh Sharanagat, and Kshitiz Kumar	
7	Mixing and Forming	253
	Monica Premi and Vishal Sharma	
8	Cleaning and Separation	307
	Farid G. Sayyad, Harish Kumar Sharma, and Navneet Kumar	
9	Storage	353
	Rajesh Kumar Vishwakarma, Navneet Kumar, Kalyani Sharma, Yogesh Kumar, and Chandrasen Kumar	
10	Processing of Cereals	415
	Pragati Kaushal and Navneet Kumar	
11	Processing of Pulses	455
	Chandrakala Ravichandran and Ashutosh Upadhyay	

12 Processing of Oilseeds 483
Mandeep Kaur, Harish Kumar Sharma, and Navneet Kumar

13 Processing of Fruits and Vegetables 535
Aamir Hussain Dar, Navneet Kumar, Shafaq Shah, Rafeeya Shams,
and Mohsin Bashir Aga

Appendix A 581

Editors and Contributors

About the Editors

Harish Kumar Sharma is a Professor at Sant Longowal Institute of Engineering & Technology (SLIET) (Deemed University) and is currently working as Director of NIT Agartala, and is founder Mentor Director of IIIT Agartala. Dr. Sharma is involved in teaching Postgraduate students and has supervised 16 Ph.D. and 37 M. Tech. students. He has published 193 papers in national/international journals/proceedings in Food Engineering/Technology, authored/edited 8 books, two proceedings, and two manuals published by reputed national and international publishing houses. He has contributed 23 chapters in books published by national and international publishing houses and visited different countries. Dr. Sharma has successfully handled several projects and successfully transferred a technology on a commercial scale. He has filed two patents and possesses two copyrights and rendered technical assistance to different industries.

Navneet Kumar is an Associate Professor and Head of the Department of Processing and Food Engineering at the College of Agricultural Engineering and Technology, Anand Agricultural University, Godhra, Gujarat, India. He is involved in teaching undergraduate and postgraduate students and has taught more than ten food-process engineering subjects so far. He has guided several master's students as a supervisor and doctoral students as a member of the advisory committees. Dr. Kumar has contributed more than 50 publications as research papers, review papers, books, and book chapters. He has been awarded Fellow of Institution of Engineers (FIE), Distinguished Service Certificate (ISAE), and best research paper award in the field of food engineering (AFSTI). He also has delivered lectures/talks on different aspects of food processing at various institutes across India. He is currently working in drying, dehydration, mathematical modeling, storage stability, traditional foods, and minimal processing.

Contributors

Mohsin Bashir Aga Department of Food Technology, Islamic University of Science and Technology, Awantipora, Kashmir, India

Aamir Hussain Dar Department of Food Technology, Islamic University of Science and Technology, Awantipora, Kashmir, India

Nilesh B. Kardile MIT ADT University, Pune, Maharashtra, India

Mandeep Kaur Amity Institute of Food Technology, Amity University Campus, Sec-125, Gautam Buddha Nagar, Noida, Uttar Pradesh, India

Pragati Kaushal Department of Food Science and Technology, Punjab Agricultural University, Ludhiana, Punjab, India

Chandrasen Kumar Food Corporation of India, New Delhi, Delhi, India

Kshitiz Kumar A D Patel Institute of Technology, Anand, Gujarat, India

Navneet Kumar Department of Processing and Food Engineering College of Agricultural Engineering and Technology, Anand Agricultural University, Godhara, Gujarat, India

Vivek Kumar Department of Food Technology, Faculty In-Charge Placement Food Technology, Harcourt Butler Technical University (HBTU), Kanpur, Uttar Pradesh, India

Yogesh Kumar ICAR-Central Institute of Post-Harvest Engineering and Technology, P.O. PAU, Ludhiana, Punjab, India

Yogesh Kumar Sant Longowal Institute of Engineering and Technology, Longowal, Punjab, India

Ajay Patel Indian Institute of Technology, New Delhi, Delhi, India

Monica Premi School of Life Sciences, Manipal Academy of Higher Education, International Academy City, Dubai, United Arab Emirates

Chandrakala Ravichandran Department of Food Processing Technology, Karunya Institute of Technology and Sciences, Coimbatore, Tamilnadu, India

F. G. Sayyad Polytechnic in Agricultural Engineering, Anand Agricultural University, Dahod, Gujarat, India

Rachna Sehrawat National Institute of Technology, Rourkela, Odisha, India

Shafaq Shah Division of Food Science and Technology, Sher-e-Kashmir University of Science and Technology, Jammu, Jammu & Kashmir, India

Rafeeya Shams Division of Food Science and Technology, Sher-e-Kashmir University of Science and Technology, Jammu, Jammu & Kashmir, India

Vijay Singh Sharanagat National Institute of Food Technology Entrepreneurship and Management, Sonipat, Haryana, India

Harish Kumar Sharma National Institute of Technology (NIT), (An Institute of National Importance), Agartala, Tripura, India

Kalyani Sharma Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Vishal Sharma Bakery Ingredients Division-IFFCO, Al Quoz, Industrial Area 1, Dubai, United Arab Emirates

Shubhangi Thakre Vasantao Naik Marathvada Krishi Vidyapith, Parbhani, Maharashtra, India

Ashutosh Upadhyay Department of Food Science and Technology, National Institute of Food Technology Entrepreneurship and Management (NIFTEM), Kundli, Haryana, India

Rajesh Kumar Vishwakarma ICAR-Central Institute of Post-Harvest Engineering and Technology, P.O. PAU, Ludhiana, Punjab, India