

SUSTAINABLE FOOD INNOVATIONS:

PRODUCT DEVELOPMENT, PACKAGING, AND WASTE VALORIZATION

**Innovations in Sustainable Food Processing,
Functional Foods and Smart Technologies**

Edited by

**Kamlesh Prasad, PhD
Shubhra Shekhar, M. Tech.
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**Sant Longowal Institute of Engineering and Technology,
Longowal – 148106, Sangrur, Punjab, INDIA**

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About the Editor

Kamlesh Prasad, PhD

Prof. Kamlesh Prasad is a distinguished academician, researcher, and food technologist with extensive experience in teaching, research, academics, administration, and scholarly publishing. He is currently serving as Professor in the Department of Food Engineering and Technology at Sant Longowal Institute of Engineering and Technology (SLIET), Longowal, Punjab, India. In addition to his academic responsibilities, he has served as Head of the Department (Food Engineering and Technology), Coordinator of the Internal Quality Assurance Cell (IQAC), Chairman of the Rajbhasha Hindi Cell, and Public Grievance Officer (PGO) of the institute. He is also the Chairman of the Conference on Future Innovations, Food Allergies, and Traditional Foods (FIFATF-2025 and FIFATF-2026).

Prof. Prasad obtained his postgraduate degree in Food Technology from the CSIR-CFTRI, Mysore. He subsequently earned his doctoral degree in Food Technology from GBPUA&T, Pant Nagar. His major areas of specialisation include fruit and vegetable processing, non-destructive quality evaluation of foods, image analysis, food process optimisation, nanotechnology applications in food systems, engineering properties of biological materials, innovative food processing technologies, and traditional foods to combat hidden hunger.

Prof. Prasad has authored and co-authored more than 200 research papers published in reputable national and international journals and conference proceedings. He has also authored several books, edited scholarly volumes, and contributed chapters to books published by leading national and international publishers. His publications have served as valuable references for researchers, students, and professionals in food science, food engineering, and postharvest technology. Also associated with several prestigious professional societies and scientific organisations, including the ASABE, IFT, AFST(I), NSI, USI, IEEE, and other national and international professional bodies. In addition to his research accomplishments, Prof. Prasad has actively contributed to academic leadership, curriculum development, student mentoring, and research capacity building.

This edited book is being published as part of the conference proceedings, reflecting his commitment to advancing research and disseminating knowledge in these critical domains.

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Mr Shubhra Shekhar is a PhD candidate in the School of Chemical Engineering at the University of New South Wales (UNSW), Sydney, Australia. He is currently a member of the Faculty Board, holds higher-degree research student positions in engineering, has served as President of the Chemical Engineering Research Society (CERS), and is a member of the AGSE Industry PhD cohort, actively engaging with both industry and academic partners. His research focuses on non-destructive sensing and advanced characterisation methods to improve quality assurance and process understanding in modern food systems. His work brings together principles from chemical engineering, computer science, and data-driven modelling to develop innovative approaches for analysing complex food products and their behaviour.

He is a GATE achiever and has completed an M. Tech. (Food Process Engineering) from NIT, Rourkela. He received the Best Student Award from the Association of Food Scientists and Technologists, India (AFSTI), Mysuru, in 2021 and ranked top in the deemed-to-be university at graduation. He was also the All-India Topper (Elite) and received a Silver Medal for the NPTEL Course conducted by IIT Kharagpur. Got an appreciation letter from Nestle India Ltd., Moga, for his contributions in the form of recommendations. Won several prizes in academics, co-curricular and extracurricular activities. Received letters of appreciation for his contributions to several events and activities. He has successfully delegated his responsibilities as the in-charge of the Society of Food Technocrats (SOFT), the Photography Club (SVIESA), and numerous other professional committees and events. He has industrial exposure with Mondelez India Foods Private Limited, Baddi, HP; Mrs Bector's Food Specialities Limited, Greater Noida, UP; and Nestle India Limited, Moga, Punjab. He is a widely travelled person and has visited countries including Australia, Switzerland, Italy, France, Vatican City, Belgium, the Netherlands, Germany, the Czech Republic, Austria, Hungary, Singapore, Thailand, and Hong Kong. His work is published as articles in books, journals, and conference proceedings of international repute.

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Harish Kumar Sharma S/o Mrs Sharda Sharma and Late Shri M. M. S. Sharma is a Professor (HAG) of Sant Longowal Institute of Engineering & Technology (SLIET) (Deemed University) (Established by: Government of India) and worked as Director, National Institute of Technology (NIT) (An Institution of National Importance), Agartala and Founder Mentor Director of Indian Institute of Information Technology (IIIT), Agartala. Professor Sharma is involved in Teaching, Research, and Administration and has published 167 papers in peer-reviewed Journals and a total of 205 papers in National/International Journals/Proceedings. He has supervised 18Ph.Ds and 44 M.Tech. students for their theses and authored/edited (10) books, (02) proceedings, and (02) manuals, published by reputed National and International Publishing Houses. He contributed 34 book chapters published by National and International Publishing Houses and visited different countries. Professor Sharma has successfully handled several projects and successfully transferred technology on a commercial scale. He has filed two patents, holds four copyrights, and provided technical assistance to various industries.

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Preface

It gives us immense pleasure to present ***Sustainable Food Innovations: Product Development, Packaging, and Waste Valorization***, an edited volume bringing together the research contributions addressing important contemporary challenges and opportunities in sustainable food processing, food product development, packaging, and resource valorization.

The food sector increasingly needs to meet growing demand for nutritious, safe, affordable, high-quality foods while using natural resources efficiently and reducing food and agricultural waste. Sustainable food innovation therefore requires approaches that integrate product development, nutritional improvement, efficient processing, waste reduction, value addition, and environmentally responsible packaging.

The book comprises fourteen chapters covering diverse themes. These include food applications for addressing celiac disease, techno-economic evaluation of wheat bran for fibre-rich food products, rice straw for sustainable packaging, utilization of underexplored banana species, food allergen reduction using cold plasma, and the nutritional and functional potential of tangerine peel waste.

Several chapters emphasize the valorization of underutilized crops and food resources. The volume includes studies on Tardi (*Dioscorea bellophylla*) starch, amla cultivars, multi-millet formulations, bitter gourd, jute leaves, asparagus bean flour, dietary-fibre recovery, and bioactive compounds from stinging nettle. These contributions show the potential of diverse plant resources and food-processing residues as sources of nutrients, functional ingredients, bioactive compounds, and value-added food products.

The book also highlights sustainable packaging and innovative processing technologies. Converting rice straw into packaging materials offers a way to create value from agricultural residue, while starch-based antimicrobial films show the potential of renewable materials for functional packaging applications. Other contributions address cold plasma treatment, drying technologies, extraction processes, and hydrothermal recovery of dietary fibre.

An important feature of this volume is its multidisciplinary approach, bringing together perspectives from food technology, food engineering, agricultural sciences, nutrition, biotechnology, materials science, and related disciplines.

We hope that “*Sustainable Food Innovations: Product Development, Packaging, and Waste Valorization*” will serve as a useful reference for researchers, academicians, postgraduate and doctoral students, food technologists, engineers, industry professionals, and other stakeholders.

We sincerely thank all the authors, reviewers, institutions, colleagues, students, and supporters whose contributions have made this volume possible.

K. Prasad, S. Shekhar, and H. K. Sharma (Editors)

Acknowledgement

The publication of *Sustainable Food Innovations: Product Development, Packaging, and Waste Valorization* has been made possible through the collective efforts, cooperation, and support of numerous individuals and institutions. As editors, we sincerely acknowledge everyone who contributed to preparing and completing this volume.

First, we express our heartfelt gratitude to all the contributing authors for sharing their research findings, knowledge, and expertise. The fourteen chapters covering sustainable food product development, agricultural and food-waste valorization, sustainable packaging, functional ingredients, food allergen management, processing technologies, nutritional enhancement, dietary-fibre recovery, and bioactive compounds form the foundation of this book.

We sincerely thank the reviewers and subject experts for their valuable time, critical evaluation, and constructive suggestions. Their scholarly inputs have helped improve the quality, scientific content, and presentation of the chapters.

We gratefully acknowledge Sant Longowal Institute of Engineering and Technology (SLIET), Longowal, for providing the institutional support and academic environment necessary for this scholarly initiative. We particularly appreciate the support of all FIFATF-2025 sponsors in bringing this edited volume to publication.

We also acknowledge the valuable contribution of the Department of Food Engineering and Technology, SLIET, Longowal, whose academic and research environment continues to encourage innovation and knowledge dissemination in food engineering and technology.

We extend our sincere thanks to the collaborating institutions and academic partners whose researchers contributed to this volume. We particularly acknowledge the association of researchers from national and international institutions.

We thank our research scholars, students, faculty members, colleagues, collaborators, and well-wishers for their valuable support, encouragement, and academic contributions. We also appreciate the efforts of all those who assisted with manuscript preparation, editing, compilation, formatting, proofreading, correspondence, and publication. Special thanks to my scholars, Gunjan Thakur and Sunil Kumar, for their efforts in shaping this book in its present form.

Finally, we express our heartfelt gratitude to our families and friends for their patience, encouragement, and continued support throughout the preparation of this book. Thanks are also extended to the administrations of the institute and the Ministry of Food Processing Industry for their support.

We sincerely hope that this volume will contribute to advancing research and innovation in sustainable food product development, resource-efficient processing, sustainable packaging, agricultural and food-waste valorization, nutritional enhancement, and the development of environmentally and economically sustainable food systems.

K. Prasad, S. Shekhar, and H. K. Sharma (Editors)

Innovation in Wheat Bran Modification: A Techno-Economic Analysis for the Development of Fiber-Rich Food Products

Praveen Saini[✉], Akhouri Sanjay Kumar Sinha[✉] and Kamlesh Prasad[✉]

Abstract. Present study is on the comprehensive techno-economic analysis (TEA) for the commercial viability of a novel wet refining process to valorize underutilized wheat bran into high-value functional food products. The analysis is based on a pilot-scale plant with a capacity of 10 kg/h of raw wheat bran (RWB), designed to produce two distinct consumer goods: a savoury Ready-to-Use (RTU) powder formulation and high-fiber cookies. The wet refining process utilized found to significantly enhance the nutritional profile of the bran, increasing its total dietary fiber content from 41.63% to 70.22%. The financial model was developed for a 10-year operational lifetime, incorporating conservative, market-aligned assumptions. This includes wholesale-realized product prices of Rs. 220/kg for the RTU powder and Rs. 180/kg for the cookies, a phased market ramp-up achieving a steady-state utilization of 80%, and a detailed operational cost structure. The results indicate a total initial capital outlay of Rs. 1.68 crore, inclusive of working capital. The base-case financial projections show the project is highly viable, with a payback period of approximately 3.19 years, an Internal Rate of Return (IRR) of 40.2%, and a Net Present Value (NPV) of Rs. 2.67 crore at a 12% discount rate. A multi-variable sensitivity analysis confirms the project's financial resilience, demonstrating profitability even under pessimistic market conditions. The study concludes that the proposed venture is technically sound and financially robust, presenting a compelling investment opportunity. The critical path forward involves securing regulatory approval from the Food Safety and Standards Authority of India (FSSAI) for the modified bran as a novel food ingredient.

Keywords: Techno-Economic Analysis (TEA), Wheat Bran Valorization, Wet Refining, Functional Foods, Dietary Fiber.

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1. Introduction

Developments have made people more aware of the importance of a healthy diet in preventing lifestyle-related disorders. Several factors, including dietary fiber, help in the improvement of gut health, control blood sugar levels, and reduce the risk of obesity and heart diseases (Kumar et al., 2026; Prasad et al., 2022; Saini et al., 2023a). Despite of abundant fiber in nature, many people do not get enough fiber in their daily diet (Cheng et al., 2022; Islam et al., 2023). To help solve this problem, two wheat bran-based fiber-rich products can be useful: ready-to-use (RTU) fiber-rich powder and fiber-rich cookies (Asadi et al., 2021; Indriati et al., 2021; Olawoye et al., 2017; Saini et al., 2025b). Wheat bran-based RTU fiber-rich powder is a convenient product that can be easily added to different foods. It provides a simple way to increase fiber intake without changing the taste or texture of meals (Burgos-Araiza et al., 2022; Sharma et al., 2016). It can be used by mixing with foods like smoothies, soups, bread, and other everyday recipes. This makes it an easy option for those looking to improve their fiber intake without making big changes to their diet. On the other hand, wheat bran-based fiber-rich cookies offer a ready-to-eat snack option for people who want a healthier alternative to regular cookies. Traditional cookies are often made with refined flour and sugar, which provide little nutritional value. In contrast, fiber-rich cookies contain wheat bran, which makes them a better choice for digestion, weight management, and overall health (Asadi et al., 2021; Sozer et al., 2014). These cookies are a convenient and tasty way for people to get more fiber in their diet.

The demand for healthy and functional fiber rich foods is growing as more consumers seek nutritious and convenient food options (Prasad et al., 2008; Prasad and Nirgude, 2025; Ramteke and Prasad, 2026). The RTU fiber-rich powder is beneficial for those who prefer to add fiber to their meals, while fiber-rich cookies serve as an easy snack alternative. Both products have strong market potential as people become more conscious of their food choices.

Studies on technical and economic feasibility analysis have received relatively much attention from academics across various industrial fields, including agro-based and food processing industries. Techno-economic feasibility is a crucial assessment that evaluates the viability of a product or process by integrating both technical and financial considerations. In food

Table 8 Sensitivity Analysis of Key Financial Metrics

Case scenario	Main changes	IRR	Payback period	NPV @ 12% (Rs)
Best case	+10% selling price, -10% raw material cost, 85% utilization from yr 3	60.3%	2.18 yrs	Rs 4.97 Cr
Base case	As per model	40.2%	3.19 yrs	Rs 2.67 Cr
Worst case	-10% selling price, +15% raw material cost, 70% utilization from yr 2	12.9%	9.74 yrs	Rs 0.07 Cr

4. Conclusion and Recommendations

The techno-economic analysis of the project to produce modified wheat bran (MWB) functional foods confirms the technical and financial suitability. By incorporating conservative, market-aligned assumptions, the model demonstrates that the venture remains a robust and attractive investment. The project's key strength is the significant value addition of converting a low-cost agricultural by-product into differentiated consumer products that cater to the growing health and wellness market in India. The financial metrics: a payback period of approximately 3.19 years and an IRR of 40.2% are both representative and convincing for a pilot-scale food manufacturing project. The sensitivity analysis further reveals that the project has a strong margin of safety and does not register losses even under pessimistic market conditions. The project represents a significant commercial opportunity with a robust scientific foundation and exceptional financial promise. Careful execution of the pilot phase and proactive navigation of the regulatory landscape will be key to realizing its full potential. The financial projections clearly support moving forward with the Rs ~1.68 Cr investment to set up the pilot plant. To ensure profitability, it's essential to manage raw material costs effectively and maintain pricing power, this means securing a reliable supply chain and building a strong brand presence. At the same time, the most urgent priority should be obtaining regulatory approval from the Food Safety and Standards Authority of India (FSSAI) for the MWB as a novel food or non-specified food ingredient. Initiating this process immediately will be key to launching the product on time and gaining early market traction.

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SUSTAINABLE FOOD INNOVATIONS:

PRODUCT DEVELOPMENT, PACKAGING, AND WASTE VALORIZATION

Innovations in Sustainable Food Processing, Functional Foods and Smart Technologies

This book presents recent research and innovative applications in sustainable food product development, packaging and waste valorization. It explores the utilization of biodegradable crops, food processing by-products and agricultural residues, development of functional and specialized food products, sustainable packaging materials, and emerging processing technologies. The chapters highlight multidisciplinary approaches integrating food science, food engineering, nutrition, biotechnology and materials science for resource-efficient, environmentally sustainable and value-added food systems. The volume serves as a useful reference for researchers, academics, students, industry professionals and Policymakers working towards innovations in sustainable food processing, functional foods and smart technologies.

KEY TOPICS COVERED

- Sustainable food product development and functional foods
- Utilization of undervalued crop and food processing by-products
- Agricultural residue conversion and waste valorization
- Sustainable and biodegradable packaging materials
- Food allergen reduction and processing technologies
- Nutritional and bioactive potential of fruits, vegetables and herbs
- Dietary fibre recovery and value-added ingredients
- Techno-economic analysis and scalability
- Innovative drying, extraction and processing methods
- Applications of smart and sustainable technologies in food systems

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