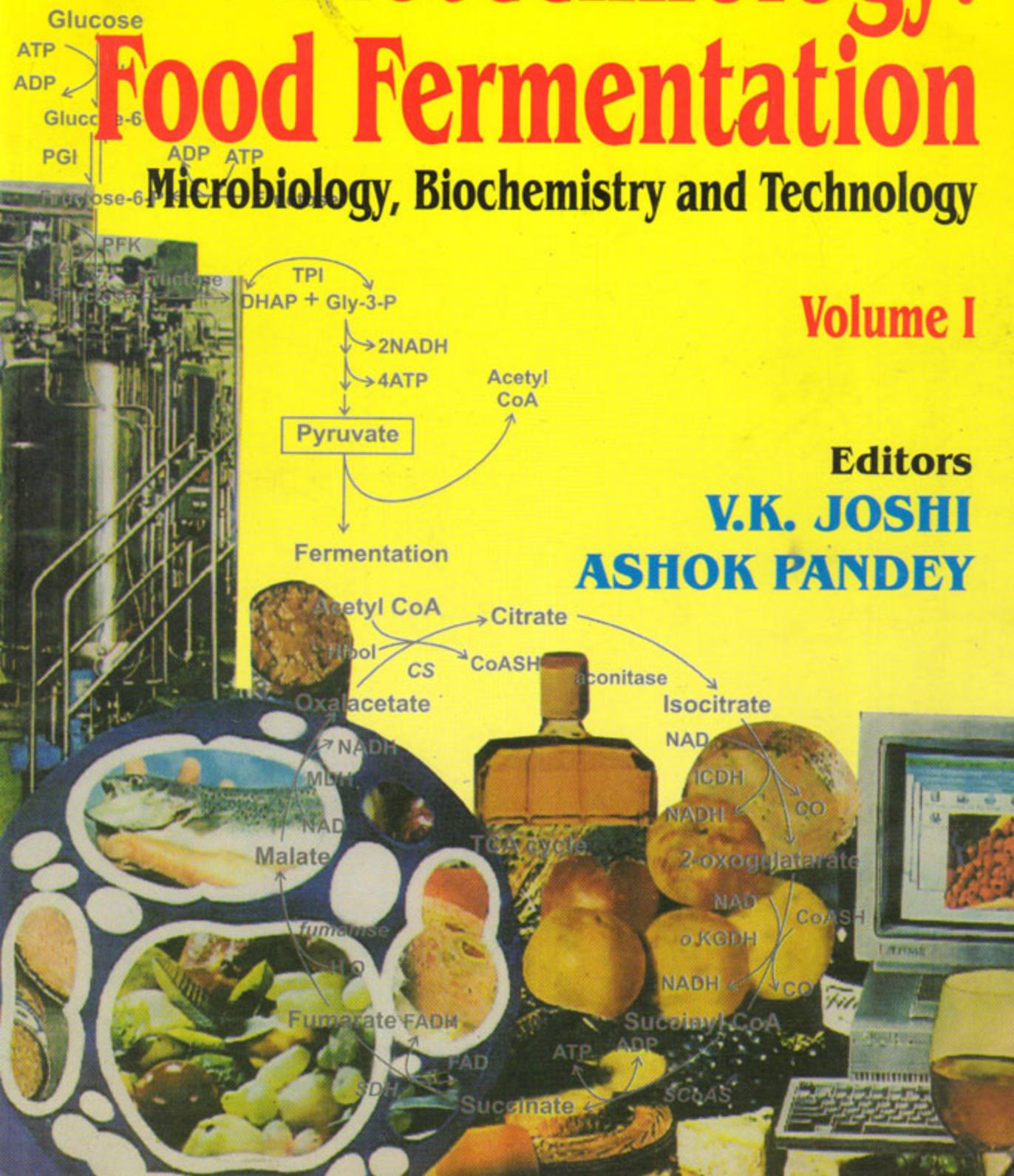


Biotechnology: Food Fermentation

Microbiology, Biochemistry and Technology

Volume I

Editors
V.K. JOSHI
ASHOK PANDEY



Biotechnology: Food Fermentation

(Microbiology, Biochemistry and Technology)

Vol. I : Basic

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*DEDICATED
TO
LOUIS PASTEUR (1822-1895)
The Great French Scientist
Whose Discoveries in FERMENTATION...
Proved to be A MILESTONE...
in the development of MODERN FOOD FERMENTATION,
Inspired and Steered
THE SCIENTIFIC COMMUNITY World-over.*

THE EDITORS

DR. V.K. JOSHI

V. K. Joshi is M.Sc., Ph.D. (Microbiology) from Punjab Agricultural University, Ludhiana and Guru Nanak Dev University, Amritsar, respectively with more than 20 years experience in Fruit Fermentation Technology, Quality Control and Waste Utilization. Received training on 'Sensory Analysis' from CFTRI, Mysore; 'Food Processing & Nutrition' from MAU, Parbhani, 'Postharvest Technology of Fruit and Vegetables' from PAU, Ludhiana, organised by USAID and University of Agricultural Sciences, California, Davis (USA). Dr. Joshi has published 3 books (including the present), besides presenting 30 papers in different conferences 95 research papers in international and national journals, 25 book chapters, 32 review / technical popular articles.

He is a recipient of 'NN Mohan Memorial Award' for the best research (1982) paper. He has guided PG students for their dissertations in Postharvest technology (Fermentation) and is engaged in active research and teaching at the University of Horticulture and Forestry, Nauni-Solan, (HP), India, as an Associate Professor. Dr. Joshi remained a member of Board of Studies HPU, Shimla and College of Horticulture, UHF, Nauni Solan, core committee of SLIST, Longowal (Punjab). He is a wine consultant. He has been elected a member of US Academy of Sciences, New York. Dr. Joshi has been honoured with 'Kejeriwal Award' for the best research paper of interest to the Food Processing Industry for the Year 1995 and 'N.A. Pandit Award' (1996) by AIFPA, New Delhi.

He has been selected as the 'Man of the Year, 1998' by the American Biographical Institute, Inc., USA. His biography is included in 15th Edn. of WHO's WHO IN THE WORLD, MARQUIS WHO'S WHO, FIVE HUNDRED LEADERS OF INFLUENCE, by ABI, USA. He is a member of ABI's Research Board of Advisors.

He co-edited the special issue 'Frontier in Biotechnology (1998), Journal of Scientific and Industrial Research, NISCOM.

He has successfully handled the research projects of Indian Council of Agricultural Research (AICRP and Cess Fund), and National Horticultural Board, New Delhi. Has been a reviewer for research projects of various funding agencies including ICAR and various scientific journals.

DR. ASHOK PANDEY

Ashok Pandey, D. Phil. is Head, Biotechnology Division at the Regional Research Laboratory (RRL), CSIR, Trivandrum. At present, he is a visiting Professor, Laboratorios de Processos Biotecnologicos, Dept. Engg. Quimiea, UFPR, CURITIBA-BRAZIL. Born on 1st January 1956 at Kanpur, Dr. Pandey graduated from Kanpur University and took his D. Phil. degree from the University of Allahabad in 1979. In

1982, he joined the Biochemistry Division of National Sugar Institute, Kanpur as Scientist and in 1985 he moved to Germany to work as a 'Research Scientist' in Zentral Laboratorium, Suddeutsch Zucker AG, Gruenstadt. In 1987, he returned to India to join RRL, Trivandrum. He is actively involved in Biotechnology, R & D and consultancy since past 22 years. He is recipient of many national and international awards and fellowships including 'Young Scientist Award' in 1989, 'GBF', Germany and CNRS, France fellowships in 1992—1993 and 'Raman Research fellowships Award' in 1995. He has been selected as the 'Man of the Year—1997' by the American Biographical Institute Inc., USA. His Biography has been included in the 14th edition of WHO'S WHO IN THE WORLD, Marquis Publication, USA, and in 13th edition of WHO'S WHO IN INTELLECTUALS, International Biographical Centre, Cambridge, UK. Dr. Pandey has visited many laboratories and institutions in Germany, Italy, France, Greece and UK. He has published 150 papers including patents, policy/review, and original research papers; has guided research work leading to Ph. D. and M. Sc. degrees (Biotechnology) as also a dozen short term research training projects in Microbiology, Biotechnology and Pharmacology. He has edited three books and prepared several technical reports. He has also written a popular science book on *Threads of Life*. He is *ad-hoc* reviewer for grants for various scientific departments of India and for research publications for many international journals. He has been on Editorial Board of four journals (presently three), including two international journals. He has been Guest Editor for the special issues of Journal of Scientific and Industrial Research in 1996 and 1998. He is member of several committees at different levels. His research interests are in the area of Industrial Biotechnology.

PREFACE

The man learnt the art of fermentation more as an accident than the result of a systematic investigation. As an agriculturist, he faced the problem of storage of a large quantity of surplus agricultural produce and the necessity invented the process of fermentation, and he became the first '**Biotechnologist**'. Later on, with the development of taste, the fermented products became indispensable part of his food. Undoubtedly, the first fermented product prepared and consumed by the ancient man was the fermented juice or the wine, which became intimately connected with the human civilization and is the most important fermented product consumed by man even today. The wide acceptance of the fermented products as a food further accelerated the development of the fermentation industry as a part of the food industry which originated in the medieval empiricism, lacking the intellectual stimulus of genetic manipulation and sophisticated bioengineering of 20th century science. Application of fermentation as a low cost preservation technique, has immense potential in the developing countries where a huge quantity of perishables are wasted, owing to the lack of proper postharvest infrastructure. Some of the fermented products have been and could be a great source of nutrition, besides palate satisfaction.

The food fermentation industry utilizes the ability of growth of micro-organisms on various substrates for the production of fermented foods, a variety of beverages, bread, cheese, idli, dosa, tofu, tempeh and fruits, and vegetable fermented pickles. The ever increasing knowledge about the microbial metabolism has extensively been used in the industrial production of different additives. Microbial systems, due to development of sophisticated and specialized methods for survival in nature, interact and metabolize and or synthesize a wide variety of substrates, both from the microorganisms existing in nature or those genetically engineered. The latter methodology has certainly opened new avenues for wider applications including higher potential for their utilization in the production of ingredients and processing aids for the food industry (vitamins, amino acids, flavours, sweeteners, xanthan/gums). It is an area where fermentation has a great role to play in future also.

A considerable research has been directed on the screening of useful microorganisms, biochemistry of fermentation, development of specific processes, machinery and equipment in the usage of fermentation processes, methods for toxicity assessment, spoilage prevention, nutritional evaluation, modification of flavour and taste, maturation process, microbe based colours or other such additives. The application of biotechnologically altered micro-organisms, enzymes production, immobilized enzymes, continuous fermentation, solid state fermentation, single cell proteins etc. are some of the recent approaches in food fermentation industry which can enhance the economic returns. The value of a technology without commercial realization is nil as the calorific value of food which is not eaten is zero. Strong

linkage between the research and industry is most essential but it is not universal as several industrial units are based more on the practical skills rather than the sound scientific knowledge. A research based manuscript is one of the strongest links between the research and industry for percolation of research into the industry, as such or through the trained manpower to man the industrial enterprises.

One can find a number of publications dealing with biotechnology, microbiology of fermentation, food science and technology, technology of wine making and chemical engineering aspects of fermentation except that dealing exclusively with food fermentation technology covering its different facets. The sole purpose of writing this book is to present in concise yet comprehensive manner 'Food Fermentation technology' as a distinct discipline to the readers of diverse origin but of the same goal. While the basic nature as a text book is maintained, ample opportunities to the readers to go into the details are afforded in the form of review of literature and the latest references.

The manuscript has 32 chapters in two volumes written by the known experts in their respective field of specialization. The contributors were requested to start from the initial introductory levels and come to the present status of the research findings indicating gaps in the knowledge, giving emphasis on microbiology, biochemistry and discuss technology, describing unit operations of the process with laying stress on the future projections of their respective areas. One can find various aspects of food fermentations, their nature and origin, fermented food products, types of fermentation, microbiological aspects biochemical reactions and pathways, equipments, packaging, quality of fermented products, sensory quality, microbial flavour and colour or other additives, use of microorganisms in waste utilization, microbial toxins, biogas production, economics of fermented products etc. in various chapters of this book. Efforts have been made to present each chapter well documented and illustrated. To make the chapter complete in itself some information may be similar to that in other chapters but considering the subject matter as a whole, should not be considered repetitive. We earnestly believe that all the authors have done their best to meet our demands as well as to do justice with their respective subject. We thank warmly all the contributors who have met gladly our requests for changes in their respective MSS from time-to-time. It is sincerely hoped that the manuscript would serve the purpose for which it has been written. We would however, welcome constructive criticism of the same to improve upon it.

We are grateful to Dr. (Mrs.) D.K. Sandhu for her inspiration, scholarly annotations and constructive suggestions to improve upon the contents of the book. V.K. Joshi expresses his sincere gratitude to Prof. L.R. Verma, Vice Chancellor Dr. Y.S. Parmar University of Hort. & Forestry, Dr. M.R. Thakur, the Founder Vice-Chancellor, Dr. P.K. Khosla, Director of Extension Education, Dr. R.P. Awasthi, Director of Research of Dr YS Parmar Univ. of Hort. & Forestry, Nauni, Solan for their support and encouragement from time to time. Encouragement received from Prof. R.S. Sandhu and Prof. V.P. Bhutani is thankfully acknowledged. Inspiration from his father late Sh M.L. Joshi and mother Mrs. Bimla Joshi, has been the greatest source of strength to undertake this assignment. Grateful thanks are due to his wife Mrs. Sushma, sons Rimpu and Tinkoo, for their understanding, and invaluable and ungrudging support.

Assistance received from Dr. P.K. Khanna, Dr. S.S. Marwaha, Dr. S.C. Tiwari, Dr. Y.S. Negi, Dr. R.K. Goyal, Dr. K.P. Raverkar, Dr. S.K. Soni, Dr. T.C. Bhalla, Mr. J.C. Bhardwaj, Ms. Anju Bhat, Mr. Shashi Bhushan, Mr. Somesh Sharma, Ms. Shiwali Thakur, Mr. Siby John, Mr. Devrajan, Mr. Satish, Mrs. R. Sharma, Sh. M.L. Sharma and Mr. Parkash Chand is thankfully acknowledged.

Ashok Pandey is grateful to his *Guru*, Professor K.P. Tiwari, Allahabad University, his parents, late Mrs. Heeradevi Pandey and Sri Amarnath Pandey, and brother-in-law, Sri Surya Kant Tewari for the confidence they developed in him and for making him worthy of present day's ability. Although words won't be sufficient to compensate the sacrifices made by his wife, Sushma and children, Rahul and Neha, it would be most appropriate to place on records their co-operation and help in this endeavour. He is also thankful to Dr. Vijay Nair, Director, Regional Research Laboratory, Trivandrum, for his support and encouragement. Finally, we take this opportunity to thank Sh. N.K. Muraleedharan, Managing Partner, Educational Publishers and Distributors, Sh. Arvind Mishra and his team for doing the excellent job of timely and beautifully bringing out this book.

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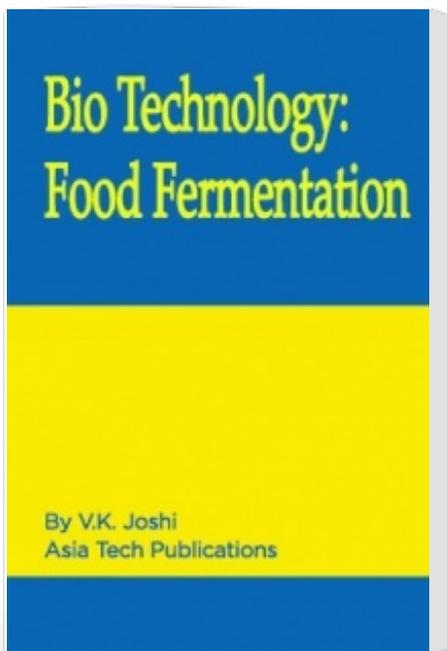
**V.K. Joshi
Ashok Pandey**

TO THE READERS

A few features of the book are intended to enhance its usefulness, both as a text and a reference book.

- Pagination of volumes I and II of this text is consecutive, with the first chapter of Volume II (Chapter 13) beginning on page 523. Broad content of all the chapters, appear in both the volumes.
- The index at the end of this volume covers both the volumes and is included in both the volumes for the convenience of readers.
- Important terms and definitions in the text are highlighted either as bold face type or in italics at the point in a chapter where the first full definition and major discussion of each term occurs. Bold face type is also used in the references to identify the name of the journal / book / seminar etc.
- The headings with numbering have been included to facilitate the readers better comprehension of the subject matter. Each chapter has been subdivided into several major sections set-off by brief headings, to help organize the material. A complete list of all the headings/subheadings of all the chapters of a volume are found in the detailed contents.
- Future trend/thrust/conclusion at the end of each chapter is to stimulate the readers for more thinking on the specific aspects.
- The citations of the references within the text appear as superscript numbers. References at the end of a chapter provide a bridge to the scientific literature and convenient way to find more detailed information on the specific aspect. The cited references include both the original papers as well as a selection of more recent review papers or other literature.
- Colour plates are included in both the volumes to give the reader an idea of actual situation.

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