

Textbook of PROBIOTICS

is intended to meet the basic requirements of students of food science and technology, food chemistry, food microbiology, food engineering and biotechnological aspects and also other professional courses at undergraduate level. It adheres to the syllabi of various Indian universities facilitating undergraduate and postgraduate courses in food science and technology and other amalgamated similar professional course outlines.

The subject matter is classified into 19 chapters under four Sections (I to IV).

- Usage of Probiotics in Food Products,
- Probiotics in Biotechnological Aspects, and
- Probiotics in Healthy,
- Probiotics in Aquaculture.

Salient Features

1. Subject matter is presented in a logical, simple, and lucid language.
2. Accurate, explicit, and balanced views on various concepts discussed.
3. Substantiated with detailed illustrations for explaining the fundamentals.
4. Each chapter is supplemented with elaborated footnotes, references, etc. to benefit the end-users.

A considerable number of solved problems for self-evaluation



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Kar



Ashutosh Kar

Textbook of PROBIOTICS

for Students in Food Technology, Food Chemistry, Food Microbiology,
Food Engineering and Biotechnological Aspects in all Indian Universities



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Textbook of Probiotics

Textbook of Probiotics

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to
my beloved and revered father
(Late) Prof (Dr) Gangacharan Kar
my beloved elder sister
(Late) Ms Bharati Kar,
who took all the necessary pains and guidance
to educate me and placing me up to this level
and
my life partner
Dr (Mrs) Leena Kar

Since past 47 years, I have received tremendous love and affection from students across Nigeria, Libya, India, and indeed there can be no repayment for such things. I am simply overwhelmed by this. I owe my success to those brilliant beloved aspirants.

Ashutosh Kar

Preface

Textbook of Probiotics is largely intended to meet the inherent basic requirements of both undergraduate and postgraduate students studying food science/technology in various universities both in India and abroad. Nobel laureate Sir Elie Metchnikoff put forward the **Probiotic Concept** at the beginning of the 20th century. He perceptively proposed that regular-periodic consumption of certain ‘*Lactic bacilli*’ would certainly improve one’s *health* and *well-being* by optimizing the **Health-Promoting Activity Profiles** of **gastrointestinal (GI) microbiota** and by reducing their **potentially adverse (harmful) effects**. Amazingly, by the end of the 20th century—an entire species, *Lactobacillus reuteri*, has been shown to possess ‘**Probiotic**’ efficacy significantly. Besides, it has been amply proved and ascertained that *L. reuteri* happens to be the only *Lactobacillus* species pronounced to inhibit (*live-in*) the inherent GI-tract of almost all *vertebrates* and *mammals*; and thus, believed to have established a **sybiotic relationship** perceptively.

Nevertheless, it may be duly concluded that the discovery of *L. reuteri* broad-spectrum *probiotic efficacy* in a corresponding wide-spectrum of *hosts* has indeed:

- a. Fully validated Metchnikoff’s Probiotic Concept; and
- b. Be the outcome of development of *Newer Bioprotective* and *Biotherapeutic Applications* for improving human and animal health.

The *Textbook* has been divided into **four different** sections comprising 19 chapters in all as stated below:

SECTION I: Usage of Probiotics in Food Products

- Introduction to Probiotics
- Genetic Advantages in Health with Probiotics
- Probiotics as Nutritional Programmer for Goodness in Health and Longevity
- Development of Functional Foods
- Milk-Based Probiotic Foods and Coronary Heart Disease (CHD)
- Probiotics in Specialized Dairy Fermented Food Products

SECTION II: Probiotics in Health

- Probiotics and Reduction in Adult Lactose Tolerance
- The Cereal-Based Functional Foods: Functional Dairy Probiotic Foods Development: Trends-Concept and Products

- Development of Innovative Dairy Products Using Probiotics: Challenges and Limitations
- Milk and Dairy Products: Vectors to Make Improvised Probiotic Products
- Probiotic Confectionary Products
- Probiotic in Inflammatory Diseases
- Role of Probiotic in Gut Flora
- Prevention of Necrotizing Process

SECTION III: Probiotics in Biotechnological Aspects

- Probiotics Stabilization
- Probiotics: Types and Specifications

SECTION IV: Probiotics in Aquaculture

- Probiotics in Shrimp Larvae
- Probiotics in Biofilms

In addition, there are quite a few other emerging *areas, concepts* and *ideas* related to the beneficial applications of Probiotics *viz., Functional Food for Hepatitis C Virus (HCV), Probiotics Promote Good Health*, etc. Hence, in true sense, probiotics is indeed an interesting *thought—providing extremely advantageous source of eternal useful paradigm.*

An individual's Quality of Life is virtually linked to the *Daily Diet* and *Lifestyle*. Nevertheless, the active and prominent role of probiotics for the benefit for Human Health almost commenced as early as 1980, when Metchnikoff associated the ingestion of *Fermented Milk with Prolonged Life Span* [Lourens-Hattigh A and Viljoen BC (2001): *Dairy Journal*, 11: 1-17, 2001]. Amazingly, the prevailing relationship between intestinal microbiota as well as good health and nutrition has been duly investigated only recently. Perhaps it could be the major reason, it was not until the 1960s that the actual realistic '*Health Claims*' started its due appearance on the '**Food Labels**' globally. Therefore, in the past couple of decades, there has been an ever-increasing overall generalized interest in the segment of '**Probiotic Foods**', that has not only *stimulated innovation* but also *fueled the virtual development of Newer Food Products around the world* for the ultimate benefit of the humans. In short, it may be added that the most widely accepted, popular **Probiotic Foods** are being manufactured in the **Dairy Industry** since the *Fermented Dairy Products* do show an edge over the others to be the **most efficient delivery vehicle** for the '*Live Probiotics*' as-on-date.

The entire content of the present compendium on various vital, important, and critical aspects on 'Probiotics' has been thoughtfully categorized into **four sections** in order to explore and discuss

- Usage of Probiotics in Food Products,
- Probiotics in Health,
- Probiotics in Biotechnological Aspects, and
- Probiotics in Aquaculture.

First, it would be mandatory for one to get adequately familiarized with the intricacies of probiotics. *Secondly*, one should understand critically their reactivities *in vivo* together with their reactivities and/or full of fine details of various range of reactions. *Thirdly*, it would be an absolute necessity to explore the profile of the enormous ability of the **Probiotics** in a progressive manner with knowledge, wisdom, skill, intellect, perseverance, and above all dogged determination.

The *Primary Objective* of this textbook is to focus critically and specifically clarify the perspective and relevance of **Probiotics** so as to help readers understand, and appreciate the precise and exact *Natural Roles, Occurrence, and Functions of Microorganisms* in the continuous phenomenon of building up the wealth of knowledge in a systematic manner.

The present textbook maintains the common style of presentation *viz.*, introduction, principles, labelled figures, graphics, diagrams, descriptions, explanations, applications, and selected classical examples. Each chapter is duly elaborated with footnotes, references, and further reading references assist and guide its interested readers.

The author sincerely believe that the *Textbook of Probiotics*, will certainly prove to be of immense help to undergraduate and postgraduate **students of food technology/science, food microbiology**, and biotechnological aspects

I extend my heartfelt thanks to Shri Satish Jain, MD, CBS Publishers & Distributors, New Delhi, for his excellent support in enabling the project to be completed in a record time frame.

Ashutosh Kar

Prologue

The entire world has critically and specifically taken cognizance of the fact that microorganisms do inhibit the intestinal tract, urogenital tract, skin, oral, and nasal cavities in a great number and diverse forms. In reality, this holds true for any part of the human body which is exposed to the external environment where the prevailing parameters are fairly favourable to bacterial survival.

Tannock (1998) demonstrated from the **Germ-Free Animals** that, in general, ‘**animals**’ do not essentially need *Microbial Colonization* for their survival; however, the *former* when duly compared with their **Conventional Counterparts**, do eventually exhibit several *physiologic and biochemical* differences; and hence, are definitely **more susceptible to infection**.

Amazingly, **Sir Elie Metchnikoff** received the Nobel Prize in 1901, who coined the ‘**Probiotic Concept**’. He vehemently proposed that the consumption of certain ‘*Lactic bacilli*’ would perceptively enhance one’s Health Profile as well as well-being by:

‘Maximizing Health Promoting Activities of the Gastrointestinal (GI) Microbiota; and thus, *minimizing their potentially harmful and injurious effects*’.

Obviously, there was a need of these intervening years to *discover, identify and ascertain* the specific strains of ‘*Lactic bacilli*’ duly capable of accomplishing these ‘**Probiotic**’ tasks effectively.

However, its just a couple of decades ago that it was discovered that an entire species, *Lactobacillus reuteri* possess the respective **Probiotic efficacy**. As-on-date, *L. reuteri* is recognized to be the only *Lactobacillus* species duly reported to inhibit the **GI tract** of all vertebrates and mammals, ranging from birds to humans, and with whom it is believed to have established a **Symbiotic relationship**. In short, *L. reuteri* does confer ‘**a Broad-spectrum** protection against disease in humans and animals’.

Since 1980, the **Probiotic** (*health-promoting*) microorganisms have been included rather progressively in an array of **Food products**, especially in **Fermented Milks and Yogurts**. It is an absolute necessity that several aspects *viz.*, **Safety Profile, Functional Aspects**, and **Technological Characteristics** need to be taken into consideration in the critical and specific *selection process of probiotic microorganisms*. However, the cardinal *safety features* essentially comprise for instance:

- **Origin (Healthy Human GI Tract)**
- **Non-Pathogenicity Status** and
- **Antibiotic-Resistance Characteristics**

The perceptive application of **Probiotics to Yogurt**, invariably being referred to as the ‘**Bio-Yogurt**’ as well as the effectiveness of **Yogurt** as the vital and important **Probiotic Carrier Food**. Besides, several equally predominant episodes *viz.*, **Production of Bio-Yogurt, Survival of Probiotic species in Yogurt during retail storage, Technical Considerations for Adding Probiotic**

Microorganisms into Yogurt, Starter-Culture Technology, and Enumeration of **Probiotic Microorganisms** should be taken into consideration.

Interestingly, **Probiotic and Native Bacteria** use the same underlying mechanisms to enhance or stabilize the normal colonizing microbes.

- **Protective Functions**—they usually comprise Displace Pathogen, Competes for Receptor Sites with pathogens, Nutrient Competition and Production of Antimicrobial Substances.
- **Structural Functions**—these essentially consist of Immune System Development, Reinforce Intestinal Barrier Effects, and Intestinal Cell Health and Development.
- **Metabolic Functions**—they mostly comprise Acid Digestion; Produce Organic Acids that inhibit Pathogens, Synthesize Vitamins, Increase Mineral Absorption; detoxifying Carcinogens, and Salvage Energy.

Interestingly, the term ‘**Probiotic**’ is used to describe particularly the respective **Food Supplements** specifically conceptualized and intelligently designed to Improve Health; however, the term dates back to 1974 when Parker used it to expatiate and describe:

‘Growth Promoting Animal Feed Supplements’.

The fundamental belief in the beneficial effects of the **Probiotic Approach** is based upon the knowledge that the *Intestinal Microflora* provides critical and specific protection against **various human diseases**. The evidence for this, so obtained, is rather impossible to deny or disprove; and comes from several sources eventually. Another vital and important source of evidence that duly supports the underlying fact is that:

‘the Protective Effect of the Gut Flora is the finding that Antibiotic-treated humans may eventually become more susceptible to disease viz., pseudomembranous colitis (caused by Clostridium difficile), proved to be a consequence of Antibiotic treatment’.

Evidence from the literature reveals that there has been a long strategic history of *Health Claims* pertaining to the *Living Microorganisms* present in **food products**—particularly the **lactic acid bacteria**. The *Old Testament* (Genesis 18:8) states that- ‘**Abraham owed his longevity to the consumption of Sour milk**’.

The Roman Historian ‘**Pilnius**’ (76 BC) recommended the administration of **Fermented Milk Products**—for the treatment of *gastroenteritis*; and the advent of the **Microbiology Era**—eventually attributed such *Beneficial Health Effects to shift the Intestinal Microbial Balance*. **Schaafsma G (1996)** pronounced that: ‘*Oral Probiotic* do represent in the *Living Microorganisms* which upon ingestion in certain numbers, do exert *Health Effects* beyond inherent *Basic Nutrition*’.

Probiotics are ‘*Living rugs*’ (or *Live Microorganisms* or *Microbial Admixtures*) being administered so as to improve the respective **Patient’s Microbial Balance in vivo**, specifically the environment of the **Gastrointestinal (GI) Tract** and the **Vagina**. It has been duly proven and ascertained that certain ‘**Probiotics**’ have demonstrated at least some promise as the Prophylaxis of the aforesaid type of diarrhoea. They are *Lactobacillus acidophilus*, *Bifidobacterium longum*, and *Enterococcus faecium*. Besides, the specific use of *S. boulardii* as an adjunctive treatment to therapeutic treatment with either *Vacomycin* or *Metroindazole* has been found in the respective Controlled Investigative Studies to reduce further the Recurrence of *Clostridium difficile* associated human disease.

Probiotics find their efficacy in certain other GI disorders viz., **Traveller’s diarrhoea**, **Acute infantile diarrhoea**, and **Acute diarrhoea in adults**. Amazingly, the **Putative Mechanisms of Action of Probiotics** essentially include: Production of Pathogen-inhibitory entities, Inhibition of pathogen attachment, Inhibition of action of microbial toxins, Stimulation of immunoglobulin A, and Trophic effects on intestinal mucosa. Effective use of **Probiotics** could perceptively reduce the patient’s exposure to **Antimicrobials**.

Ashutosh Kar

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