



# Recent Advancements in the Development of Modern Probiotics for Restoring Human Gut Microbiome Dysbiosis

Roshan Kumar<sup>1,2,3</sup> · Utkarsh Sood<sup>1,4</sup> · Vipin Gupta<sup>1,4</sup> · Mona Singh<sup>5</sup> · Joy Scaria<sup>2,3</sup> · Rup Lal<sup>1,4</sup>

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**Abstract** A healthy gut is predominantly occupied by bacteria which play a vital role in nutrition and health. Any change in normal gut homeostasis imposes gut dysbiosis. So far, efforts have been made to mitigate the gastrointestinal symptoms using modern day probiotics. The majority of the probiotics strains used currently belong to the genera *Lactobacillus*, *Clostridium*, *Bifidobacterium* and *Streptococcus*. Recent advancements in culturomics by implementing newer techniques coupled with the use of gnotobiotic animal models provide a subtle ground to develop novel host specific probiotics therapies. In this review article, the recent advances in the development of microbe-based therapies which can now be implemented to treat a wide spectrum of diseases have been discussed. However, these probiotics are not classified as drugs and there is a lack of stringent law enforcement to protect the end users against the pseudo-probiotic products. While modern probiotics hold strong promise for the future, more rigorous regulations are needed to develop genuine

probiotic products and characterize novel probiotics using the latest research and technology. This article also highlights the possibility of reducing antibiotic usage by utilizing probiotics developed using the latest concepts of syn and ecobiotics.

**Keywords** Probiotics · Prebiotics · Synbiotics · Ecobiotics · Challenges · Microbiota · Dysbiosis

## Introduction

The human gastrointestinal tract (GIT) fosters a plethora of microorganisms in a range of relationships varying from commensal to symbiotic to pathogenic [1]. This collection of bacteria, archaea, eukarya, and viruses collectively form gut microbiota and any changes in the normal microbial homeostasis impose a great threat on gut integrity and cause dysbiosis [2, 3]. So far the exact number of microbes in the human body, especially in the GIT, has not been settled [4, 5]. Even if we agree with the newly revised estimate which suggests that the humans are 50% microbial *i.e.*, the ratio of human ( $3.0 \times 10^{13}$ ) and bacterial ( $3.8 \times 10^{13}$ ) cells are approximately 1:1.3, with maximum abundance in the colon ( $10^{14}$ ) followed by saliva and dental plaque ( $10^{12}$ ), still the role of microbes in shaping the regulatory and metabolic networks remain imperative [6, 7]. It is now a well-established fact that the microbiota maintains human health primarily by shaping the gut epithelium [8], increasing efficient energy harvesting potential [9], protecting against pathogens [10] and regulating host immunity [11].

Based on the information available of the normal microbiota and dysbiosis with reference to a particular disease, the normal gut microbiota can be restored to

Roshan Kumar, Utkarsh Sood and Vipin Gupta have contributed equally to this work.

✉ Rup Lal  
ruplal@gmail.com

<sup>1</sup> PhiXGen Private Limited, Gurugram, Haryana 122001, India

<sup>2</sup> Department of Veterinary and Biomedical Sciences, South Dakota State University, Brookings, SD, USA

<sup>3</sup> South Dakota Centre for Biologics Research and Commercialization, Brookings, SD, USA

<sup>4</sup> Department of Zoology, University of Delhi, Delhi 110007, India

<sup>5</sup> Special Centre for Molecular Medicine, Jawaharlal Nehru University, New Delhi, Delhi 110067, India