Probiotics and Antimicrobial Proteins
https://doi.org/10.1007/s12602-019-09608-8

Potential Probiotic *Lactobacillus rhamnosus* (MTCC-5897) Inhibits *Escherichia coli* Impaired Intestinal Barrier Function by Modulating the Host Tight Junction Gene Response

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Abstract
Probiotic as a preventive medicine is emerging as an indispensable tool in addressing the foodborne infections or gastrointestinal disorders. The present study was sought to determine the in vitro prophylactic potential of probiotic *Lactobacillus rhamnosus* (LR: MTCC-5897) against *Escherichia coli* (ATCC 14948) induced impairment in intestinal barrier function using Caco-2 cells. Intestinal cells exposed to *E. coli* demonstrated significantly higher phenol red flux ($p < 0.05$) and concomitantly decreased TEER (0.69 ± 0.01) in contrast to control or *L. rhamnosus* (10^9 cfu/mL)-treated cells. However, *E. coli*-induced barrier hyperpermeability was restored to significant extents ($p < 0.01$) when *E. coli* were excluded, competed or displaced by probiotic LR. Similarly, exposure of Caco-2 cells to *E. coli* reduced the mRNA expression of key tight junction genes, viz. *Zo*-1, *Claudin*-1, *Occludin* and *Cingulin* which however were restored significantly ($p < 0.05$) with *L. rhamnosus* treatment during exclusion or competition than displacement assays. The protective behaviour of probiotic LR against *E. coli* can also be observed in immunofluorescent and electron micrograph where intact cellular morphology along with preserved distribution and localisation of key integrity proteins can be found in LR-treated cells in contrast to distorted and disorganised distribution observed with *E. coli* exposure. In conclusion, *L. rhamnosus* inhibited and re-established *E. coli*-impaired intestinal barrier function by improving the expression and distribution of key junction protein and hence could serve an essential food additive to address the various health complications especially those associated with gastrointestinal tract.

Keywords Intestinal permeability · *Lactobacillus rhamnosus* · Tight junctions · Transepithelial electrical resistance · Phenol red flux

Introduction

Probiotic intake in the form of food products, *beverages* or dietary supplements has shown an emerging trend nowadays due to their immense health benefits. Probiotic formulation have been shown to maintain gut microbiota diversity, stimulate the maturation of intestinal cells (enterocytes), regulate the motility of gastrointestinal tract, modulate systemic immune response, improve the process of digestion and absorption and assist in the production of secondary metabolites such as organic acids that have diverse biological functions [1]. Besides, mounting evidences have also shown that intake of probiotic supplements have immense capability to resolute problems associated with brain, gastrointestinal tract and other visceral organs [2]. Recently, substantial distortion in gut microbiota composition has been identified due to changed dietary patterns and lifestyles of modern society particularly misuse of antibiotics. This was directly linked with various gastrointestinal disorders ranging from intestinal Crohn's disease and inflammatory bowel disease to extraintestinal disorders such as systemic inflammatory response syndrome, arthritis, steatohepatitis or even multiple organ dysfunction syndrome [3]. Therefore, nutritionists and healthcare providers are looking for alternative ways to combat such health problems, and probiotic therapy has emerged as a new hope to restore such dysbiosed gut microbiota conditions. These outcomes have also prompted people across the globe to incorporate probiotic rich foods in their dietary plans as prophylactic measures so that gut microbiome would be manipulated to restore its healthy attributes.

The mechanism through which probiotic impart their health benefits to host is poorly understood, but generally it

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Published online: 15 November 2019