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Popular Article

# Millet prebiotics modulate gut microbiota and promote health

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*Millet-based prebiotic functional food can provide a means to address the growing pressures on the health care system by augmenting health through prevention rather than treatment. Therefore, health-conscious consumers are significantly recommended to consume millet-based functional foods in an effort to boost their immunity and wellbeing.*

***Keywords**: Millet, probiotics, Functional food, SCFA*

## Impact of diet on gut microbiota

The influence of diet and dietary constituents on human metabolism and health is a well-established fact. We can increasingly modify health through dietary habits and measure the effects through our microbes or metabolites. Gut microbiota (GM) are involved in a cascade of metabolic activities, and their dysbiosis is associated with the pathogenesis of both intestinal (inflammatory bowel disease, coeliac disease, and colorectal cancer) and extra-intestinal (metabolic syndrome, cardiovascular disease, neurological disease, and obesity) disorders. A favourable equilibrium of GM supplies several nutrients, regulates energy balance, modulates the immune response, and provides defence against pathogens, thus promoting host health. Functional foods are food products or food ingredients with valuable bioactive compounds that offer health benefits beyond their nutritional value and can provide further protection against chronic disease by promoting gut health. One type of functional food that has been receiving much attention is food rich in prebiotics. Therefore, there is a great interest in producing healthy prebiotic foods to improve gastrointestinal health by interacting closely with the GM.

## Cereal-based prebiotic and probiotic functional food

In the nutrition sciences today, prebiotic and probiotic functional food development is one of the most active areas of research and has encouraged food scientists to study the feasibility of cereal



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ingredients for the development of innovative cereal-based functional foods. Cereals are one of the main components of the human diet and nutrition, and their bioactive ingredients can be used as an alternative (to dairy-based products) for the development of prebiotic functional foods. Dietary fibres of cereals, especially resistant oligosaccharides and arabinoxylan, are well-recognized as prebiotics. Besides dietary fibres and resistant starch, polyphenols present in cereals are also potential prebiotic candidates. The health benefits of prebiotics are mainly attributed to shaping an individual's microbial diversity, stimulating the growth of beneficial microorganisms (probiotics), and increasing the production of postbiotics such as short-chain fatty acids (SCFA). SCFA e.g. acetate, propionate, and butyrate, are the chief end-products of prebiotic fermentation; they play important roles in modulating the intestinal barrier, mucus production, and intestinal pH regulation. SCFA are also involved in appetite, blood sugar regulation, energy expenditure, and modulation of the immune response, thus promoting metabolic health. Anti-inflammatory SCFA exerts beneficial effects on intestinal and immune cells, being important compounds for cell proliferation, cell differentiation, and gene expression. They are also signalling molecules in immunological pathways. Butyrate is the primary energy source of colonocytes, and it has an epithelial barrier function. SCFA can also induce the expression of anti-inflammatory cytokines, inhibiting inflammatory responses through inhibition of the NF-B signalling pathway. Therefore, prebiotics seem to represent an effective non-pharmacological approach to re-establish gut symbiosis and promote well-being through several signalling mechanisms to regulate barrier functions, oxidative stress, and inflammation.

**Prebiotic and Probiotic Potential of Millets**

People are continuously searching for nutrients having prebiotic and probiotic potential. In this regard, millets are suddenly back in the limelight for many reasons; millets are more nutrition-rich than other major cereals (rice, wheat, maize). They are rich sources of calcium, iron, potassium, magnesium, and zinc, as well as essential molecules such as dietary fibres, proteins, minerals, vitamins, amino acids, fatty acids, antioxidants, polyphenols, and other nutraceutical compounds, making them a promising and highly functional food ingredient. Millet grains are considered a source of traditional medicines and have the potential to develop prebiotic functional foods with probable health benefits. Millet foods are characterised as potential prebiotics and can enhance the viability and functionality of probiotics with significant health benefits; these are good for people with celiac disease and are good sources of bioactive compounds. The processing methods, like fermentation, germination, and heating, have shown an increase in the concentration of these bioactive compounds. Researchers are progressively studying the prebiotic potential of millet components, their therapeutic effects, and immunomodulatory mechanisms. A number of dietary carbohydrates and phenolic substances can modulate the structure and activities of GMs. According to research on both animals and humans, changes in the proportion of healthy bacteria in the gut are most frequently linked to



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improvements in health. Little attention has been paid to prebiotics found in whole millet-based diets, despite the fact that the majority of research into their health effects has been on isolated compounds. Several studies revealed that supplementing with millet raised levels of *Bifidobacterium* and *Lactobacillus* and decreased levels of *Escherichia coli*, *Enterococcus*, and *Bacteroides.* The prebiotics (e.g., arabinoxylan, phenolic acid-bound arabinoxylan, polyphenols, etc.) in millets have high antioxidant activities, which is critical in scavenging nitric oxide (NO) and reactive oxygen species (ROS) and reducing oxidative damage. Cytokines and pro-inflammatory signalling pathways mediate the majority of metabolic disorders, and it has been documented that millet nutraceuticals prevent these disease markers. As our understanding of the relationship between GM and metabolism deepens, the significance of various probiotic bacterial species, their involvement in various immune responses and signalling pathways, and the role of prebiotic components in maintaining health will probably become clearer.

**Conclusion and Way Forward**

There will be more interest in learning about prebiotics as awareness and acceptability among consumers worldwide continue to rise. Obtaining a detailed description of how bioactive components of millets interact and modulate GM composition and functions and what the mechanism of their biotransformation is could be a key to understanding their prebiotic and probiotic properties. The discovery of their nutraceuticals for new prebiotics as well as their immunomodulatory signaling mechanism(s) required an interdisciplinary approach. In the recent past, prebiotics research has come a long way due to the maturation of omics technologies (metagenomics, transcriptomics, proteomics, and metabolomics), bioinformatics, and systems biology tools. We argue that by applying and integrating meta-omics with systems biology tools, it is possible to monitor the fate of millet nutraceuticals, assemble data collected from the microbiota profiling upon millet consumption to absorption, and, more health or disease status. Given the current gaps in the prebiotic potential of millet-based functional foods, detailed clinical evidence, ideally through randomized controlled studies, is urgently required.

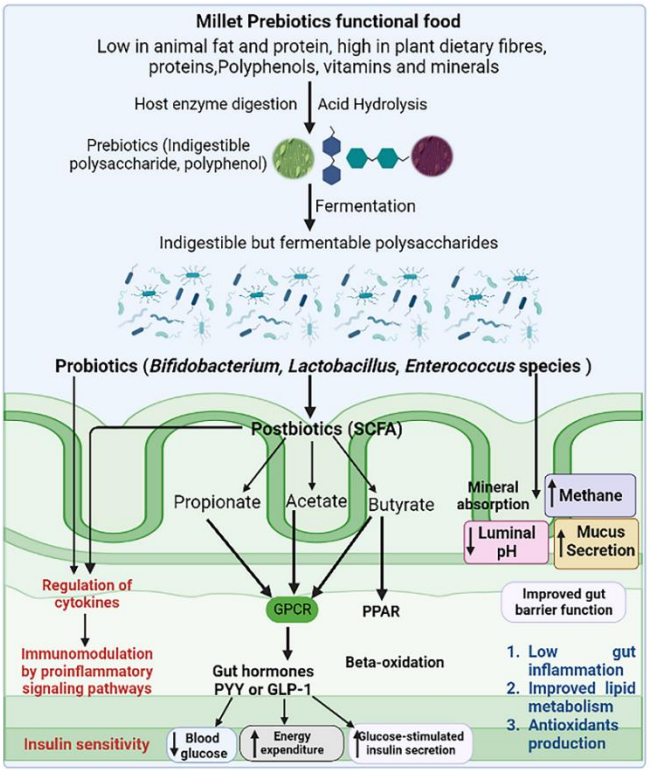


**Figure 1**. Mechanism(s) of action of millet prebiotics functional food. The health benefits of prebiotics on the host are attributed through; selectively stimulating the growth of beneficial probiotics production of postbiotics (SCFAs), which eventually regulate various cytokines and inhibit the pro-inflammatory signaling cascades.



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importantly, link the GM, host metabolome, and The outcome of these clinical trials can be translated into clinical practice to assess changes in GM composition and health outcomes.

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