

Effect of Proteobacteria in Different Diets and Composition in Individuals

Piyali Saha¹, Parul Thapar^{2*}

Department of Food and Nutrition, Swami Vivekananda University, Barrackpore, West Bengal- 7000121

*Corresponding author E-mail: parul.thapar@yahoo.com

Abstract

Proteobacteria, a phylum of gram-negative bacteria, are integral to the gut microbiome and can influence host health depending on their abundance and composition. This study explores the relationship between dietary patterns and the composition of Proteobacteria in individuals. Diets high in fats and sugars, such as the Western diet, are associated with an increased abundance of Proteobacteria, potentially promoting gut inflammation and metabolic disorders. In contrast, Mediterranean and high-fibre diets, rich in plant-based nutrients, correlate with reduced Proteobacteria levels and improved microbial diversity. Vegan diets, characterized by high fibre and plant polysaccharides, indirectly modulate Proteobacteria through increased colonization of beneficial taxa. Ketogenic diets exhibit variable effects, influenced by the composition of macronutrients and fat sources. These findings emphasize the dual role of Proteobacteria in health and disease, shaped by dietary intake, and highlight the potential of dietary strategies in managing microbiome-associated disorders.

Keywords: *Proteobacteria, gut health, Gram-negative bacteria, microbiota, diets*

Introduction

The human gut microbiome plays a crucial role in health and disease, with Proteobacteria emerging as a key phylum of interest due to its diverse metabolic capabilities and potential associations with various physiological and pathological

conditions. Proteobacteria include a wide range of Gram-negative bacteria, genus including *Escherichia*, *Salmonella*, *Helicobacter*, and *Pseudomonas*, which can function as commensals, opportunistic pathogens, or beneficial microbes depending on the host environment.

Diet is a major determinant of gut microbial composition, influencing the abundance and function of Proteobacteria. Different dietary patterns—such as Western, Mediterranean, vegetarian, and high-fiber diets—can either promote or suppress Proteobacteria populations. A Western diet rich in fats and refined sugars has been linked to an increase in Proteobacteria, which may contribute to gut dysbiosis and inflammation. In contrast, fiber-rich diets, such as the Mediterranean or plant-based diets, promote microbial diversity and may help maintain a balanced microbiome.

The composition of Proteobacteria varies across individuals due to genetic factors, lifestyle, and dietary habits. While some members of this phylum are essential for gut homeostasis and immune regulation, an overrepresentation is often associated with inflammatory conditions such as metabolic disorders, inflammatory bowel disease (IBD), and obesity. Understanding the role of Proteobacteria in different dietary contexts is essential for developing dietary interventions to promote gut health and prevent disease.

Objective

The objective of this review is to examine the effects of Proteobacteria on gut microbiome composition in individuals following different dietary patterns, as follows:

- To analyze the abundance and diversity of Proteobacteria in individuals consuming varied diets, including Western, Mediterranean, vegetarian, and high-fiber diets.
- To investigate the relationship between Proteobacteria levels and host health outcomes, including inflammation, metabolic disorders, and gut dysbiosis.
- To assess how dietary components influence the growth and activity of Proteobacteria, identifying factors

that promote or suppress their prevalence.

- To determine the role of Proteobacteria in maintaining gut homeostasis versus contributing to disease, providing insights into their potential as biomarkers for dietary impact on health.
- To explore potential dietary interventions that can help regulate Proteobacteria populations and promote a balanced gut microbiome.

Review of Literature

Role of Proteobacteria in the Gut Microbiome

Proteobacteria constitute a diverse phylum of Gram-negative bacteria (Figure 1) that play both beneficial and pathogenic roles in the human gut microbiome. Studies suggest that Proteobacteria are present in low abundance in healthy individuals but tend to increase in cases of gut dysbiosis and inflammatory conditions (Shin et al, 2015). The overgrowth of certain Proteobacteria genera, such as *Escherichia*, *Salmonella*, *Helicobacter*, and *Klebsiella*, has been linked to metabolic disorders, chronic inflammation, and gastrointestinal diseases (Mukhopadhyaya et al, 2012).



Figure 1- Gram negative bacteria

Dietary Influence on Proteobacteria Composition

Dietary patterns significantly impact the composition and abundance of gut microbiota, including Proteobacteria.

Western Diet (High-Fat, High-Sugar Diets): Research indicates that diets high in saturated fats and refined sugars promote an increase in Proteobacteria, particularly *Enterobacteriaceae*, a family associated with inflammatory responses and metabolic disorders (David et al, 2014). This diet-induced dysbiosis is often linked to conditions such as obesity, type 2 diabetes, and cardiovascular diseases.

Mediterranean Diet (High-Fiber, Polyphenol-Rich Diets): The Mediterranean diet, rich in fiber, polyphenols, and unsaturated fats (Figure 2a), has been associated with reduced Proteobacteria abundance and improved gut microbiome diversity (De Filippis et al, 2016). Studies have shown that this diet promotes beneficial bacteria such as *Bacteroidetes* and *Firmicutes*, which help maintain gut homeostasis and suppress inflammation.

Vegetarian and Vegan Diets: Plant-based diets (Figure 2b), characterized by high fiber intake, have been linked to lower levels of Proteobacteria and increased microbial diversity (Wu et al, 2011). These diets provide prebiotics that support the growth of beneficial gut bacteria, reducing the potential pathogenic effects of certain Proteobacteria strains.

High-Protein Diets: High-protein diets, particularly those rich in animal protein, have been associated with increased levels of *Proteobacteria* and bile-tolerant bacteria (Beaumont et al, 2017). This may contribute to inflammation and gut permeability, affecting overall gut health.



(a) High-fiber diet



(b) Vegan diet

Figure 2- Different Diets

Proteobacteria and Gut Dysbiosis

Several studies have suggested that an increased abundance of Proteobacteria is a hallmark of gut dysbiosis, a microbial imbalance linked to various diseases. Zhang et al, 2020 found that elevated levels of Proteobacteria are associated with inflammatory bowel disease (IBD) and other gastrointestinal disorders. Similarly, In a study by Shin et al, 2015 highlighted that the presence of *Enterobacteriaceae* correlates with systemic inflammation and metabolic syndrome.

Potential Dietary Interventions for Regulating Proteobacteria

Emerging research suggests that dietary interventions can help regulate Proteobacteria levels and restore gut balance. Probiotic and prebiotic supplementation, along with fiber-rich diets, have been shown to modulate the gut microbiome and reduce Proteobacteria overgrowth Korpela et al, 2018. Fermented foods, polyphenol-rich foods, and omega-3 fatty acids have also been linked to improved gut health by enhancing microbial diversity and reducing inflammation.

Effect of Different Diets on Proteobacteria Composition

Western Diet (High-Fat, High-Sugar, Low-Fiber): Increases Proteobacteria, especially pathogenic strains like *Enterobacteriaceae*; Promotes gut inflammation and metabolic endotoxemia; associated with obesity, insulin resistance, and inflammatory diseases.

High-Fiber Diet (Plant-Based, Whole Grains, Fruits, Vegetables): Reduces Proteobacteria abundance, supporting gut microbial balance; enhances beneficial bacteria like Firmicutes and Bacteroidetes that produces short-chain fatty acids (SCFAs), reducing inflammation.

High-Protein Diet (Animal-Based, Red Meat, Processed Meat): Increases Proteobacteria, including sulfate-reducing bacteria like *Desulfovibrio spp.*; produces harmful metabolites (hydrogen sulfide, ammonia) and associated with colorectal cancer risk and gut dysbiosis.

Ketogenic Diet (Low-Carb, High-Fat, Moderate Protein):

Alters microbiome composition, increasing *Bilophila wadsworthia* (linked to inflammation); reduces overall microbiome diversity and may improve metabolic health but has potential gut health risks.

Mediterranean Diet (Balanced, High in Healthy Fats, Fiber, and Polyphenols):

Decreases pathogenic Proteobacteria while promoting gut microbial diversity; Supports anti-inflammatory pathways and cardiovascular health and promotes a stable and resilient gut microbiome.

Individual Variability in Proteobacteria Effects

The impact of Proteobacteria varies based on:

Genetics: Some individuals have a higher tolerance for Proteobacteria.

Immune System: Those with weaker immunity may experience inflammation from overgrowth.

Microbiome Diversity: A diverse microbiome can counterbalance Proteobacteria effects.

Existing Health Conditions: People with IBD, IBS, or obesity may be more susceptible to Proteobacteria-related dysbiosis.

Conclusion:

Proteobacteria is a major phylum of bacteria found in the human gut microbiome, including both beneficial and potentially harmful species. The beneficial functions involve contribution to nitrogen cycling and digestion; help in the breakdown of certain dietary components. When found in abundance, these species tend to develop as opportunistic pathogens (*Escherichia coli*, *Klebsiella*, *Salmonella*) that are linked to gut inflammation, metabolic disorders, and endotoxin release (LPS) and found to be associated with inflammatory bowel disease (IBD), obesity, and cardiovascular disease. The focus should be given on diets that play a crucial role in shaping the composition of Proteobacteria, which in turn affects gut health, metabolism, and immune function which include increased fiber intake (whole grains, legumes, vegetables)

to support beneficial bacteria; consume Fermented Foods (yogurt, kimchi, kombucha) to enhance microbial balance; reduce processed Foods & Sugars to prevent pathogenic Proteobacteria overgrowth and diversify diet- to maintain a stable and diverse gut microbiome

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