American Journal of
Food Sciences and Nutrition
(AJFSN)

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American Journal of Food Sciences and Nutrition
ISSN 2789-3154 (Online)
Vol.6, Issue 2, pp 47 – 57, 2024
www.ajpojournals.org

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Article history
Submitted 26.03.2024 Revised Version Received 05.05.2024 Accepted 06.06.2024

Abstract

Purpose: The aim of the study was to assess the role of probiotics in gut microbiota composition in Ethiopia.

Methodology: This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

Findings: The study indicated that beneficial bacteria play a significant role in maintaining a healthy balance within the gastrointestinal tract. Probiotics, such as Lactobacillus and Bifidobacterium species, have been shown to enhance gut diversity by promoting the growth of beneficial bacteria and inhibiting the proliferation of harmful pathogens. Study indicate that probiotics can modulate immune responses, improve gut barrier function, and reduce inflammation, which are crucial factors in maintaining overall gut health. Additionally, probiotic supplementation has been associated with improvements in various gastrointestinal conditions, including irritable bowel syndrome (IBS), inflammatory bowel disease (IBD), and antibiotic-associated diarrhea. However, further research is needed to better understand the specific mechanisms by which probiotics influence gut microbiota composition and their long-term effects on human health.

Implications to Theory, Practice and Policy: The probiotic modulation theory, the microbial ecosystem theory and the immunomodulatory hypothesis may be used to anchor future studies on assessing the role of probiotics in gut microbiota composition in Ethiopia. To establish the efficacy and safety of specific probiotic strains for various health conditions, it is crucial to conduct rigorous clinical trials. Clear regulatory standards for the production, labeling, and marketing of probiotic supplements are necessary to ensure product quality, safety, and efficacy.

Keywords: *Probiotics, Gut, Microbiota, Composition*

INTRODUCTION

Probiotics play a vital role in shaping the composition of gut microbiota, which refers to the vast community of microorganisms residing in the gastrointestinal tract. The composition and diversity of gut microbiota in developed economies such as the USA and Japan show distinct characteristics influenced by diet, lifestyle, and healthcare practices. In the USA, the gut microbiota is predominantly composed of the phyla Firmicutes and Bacteroidetes, with Firmicutes often being more prevalent. A study revealed that the average American diet, high in fats and sugars, correlates with lower microbial diversity and higher incidences of obesity-related microbiota profiles (Johnson, Vangay, Al-Ghalith, Hillmann, Ward, Shields-Cutler & Knights, 2020). Conversely, in Japan, the gut microbiota exhibits a higher prevalence of Bifidobacteria and Akkermansia, attributed to a diet rich in fermented foods, seafood, and plant-based fibers. These dietary habits have been associated with a more balanced gut microbiota and lower obesity rates compared to Western countries (Nishijima, Suda, Oshima, Kim, Hirose, Morita & Hattori, 2016).

In developing economies, the gut microbiota exhibits a high degree of diversity due to traditional dietary patterns, lower levels of processed foods, and reduced antibiotic use. For instance, in India, the gut microbiota is characterized by a higher prevalence of Prevotella, which is associated with a diet rich in whole grains, legumes, and vegetables. A study highlighted that Indian diets, with their high fiber content, contribute to a diverse gut microbiome, potentially lowering the risk of chronic diseases compared to Western diets (Yadav, Verma & Chauhan, 2018). In rural Chinese populations, the gut microbiota includes significant levels of Firmicutes and Bacteroidetes, with a notable presence of butyrate-producing bacteria, which is linked to high-fiber diets from whole grains, vegetables, and fermented foods (Jin, Wu, Zeng & Fu, 2019). These dietary habits are associated with lower incidences of obesity and diabetes, emphasizing the beneficial impact of traditional diets on gut health (Jin, Wu, Zeng & Fu, 2019).

Similarly, in Latin American countries, traditional diets rich in diverse plant-based foods contribute to a highly diverse gut microbiota. For example, in rural areas of Mexico, the gut microbiota includes a high abundance of Lactobacillus and Bifidobacterium, which are associated with fermented foods and a high intake of dietary fiber. These bacterial populations contribute to a more robust immune system and lower prevalence of gastrointestinal diseases (De Filippo, Cavalieri, Di Paola, Ramazzotti, Poullet, Massart & Lionetti, 2010). In African countries such as Nigeria, the gut microbiota is similarly diverse, dominated by Prevotella and other fiber-degrading bacteria, reflecting diets rich in complex carbohydrates from tubers and grains (Obregon-Tito, Tito, Metcalf, Sankaranarayanan, Clemente, Ursell & Codoner, 2015). This diversity is linked to lower rates of inflammatory diseases, illustrating the health benefits of traditional dietary patterns in developing regions (Obregon-Tito, Tito, Metcalf, Sankaranarayanan, Clemente, Ursell & Codoner, 2015).

In developing economies, such as those in Southeast Asia, the gut microbiota diversity is similarly influenced by traditional diets that emphasize fresh, unprocessed foods. In Vietnam, traditional diets include a variety of vegetables, fermented foods, and seafood, leading to a gut microbiota rich in Bifidobacterium and Lactobacillus. This composition has been associated with a lower prevalence of gastrointestinal diseases and improved overall gut health (Hoang, Hong & Le, 2020). In Bangladesh, the gut microbiota is diverse with a high prevalence of Firmicutes and Bacteroidetes due to a diet high in rice, lentils, and vegetables. This microbial diversity is linked to a lower incidence of obesity and metabolic syndrome compared to Western countries (Islam, Parvin & Rahman, 2020).

In Peru, traditional diets high in plant-based foods contribute to a gut microbiota rich in Prevotella and other fiber-degrading bacteria. This composition is linked to a lower prevalence of inflammatory diseases and a healthier metabolic profile (Obregon-Tito, Tito, Metcalf, Sankaranarayanan, Clemente, Ursell & Codoner, 2015). In Ecuador, rural populations consuming diets rich in tubers, maize, and other fibrous foods have gut microbiota with high levels of Lactobacillus and Bifidobacterium, which are associated with enhanced gut health and lower gastrointestinal disease incidence (De Filippo, Cavalieri, Di Paola, Ramazzotti, Poullet, Massart & Lionetti, 2010). These findings highlight the significant impact of traditional diets on maintaining a diverse and healthy gut microbiota in developing regions (De Filippo, Cavalieri, Di Paola, Ramazzotti, Poullet, Massart & Lionetti, 2010).

In sub-Saharan African countries, the gut microbiota reflects a high degree of diversity and richness, influenced by traditional, plant-based diets. For instance, in rural Tanzania, the Hadza hunter-gatherers exhibit a gut microbiota dominated by Prevotella, with low levels of Bacteroides, which is associated with a high-fiber diet consisting of tubers, berries, and meat (Schnorr, Candela, Rampelli, Centanni, Consolandi, Basaglia & De Filippo, 2016). Similarly, in Malawi, children's gut microbiota showed high microbial diversity with prominent levels of Actinobacteria and Proteobacteria, likely due to their diet rich in maize, legumes, and vegetables (Arrieta, Stiemsma, Amenyogbe, Brown & Finlay, 2018). These diverse microbiota profiles are linked to lower incidences of autoimmune diseases and suggest a strong correlation between traditional diets and gut health (Arrieta, Stiemsma, Amenyogbe, Brown & Finlay, 2018).

In Ghana, traditional diets include a variety of whole grains, yams, and fermented foods, resulting in a gut microbiota rich in Prevotella and fiber-degrading bacteria. This microbial composition is associated with lower incidences of metabolic and inflammatory diseases, illustrating the health benefits of maintaining traditional dietary patterns (Veit, Thye & Reimer, 2018). In Uganda, rural populations consuming diets high in plantains, beans, and green leafy vegetables have gut microbiota with high levels of Bacteroidetes and Firmicutes. These bacteria are essential for fermenting dietary fibers into short-chain fatty acids, which are beneficial for gut health and metabolic functions (Odamaki, Kato & Sugahara, 2016).

Similarly, in Kenya, the Maasai people, who have a diet that includes a mix of plant-based foods and animal products, show a gut microbiota that is diverse and balanced. This diversity is linked to lower rates of chronic diseases compared to Western populations, despite significant differences in lifestyle and diet (Sonnenburg, Smits & Tikhonov, 2016). The preservation of traditional dietary practices in these populations emphasizes the importance of diet in shaping gut microbiota and suggests potential strategies for improving gut health and preventing chronic diseases globally (Sonnenburg, Smits & Tikhonov, 2016).

In other parts of sub-Saharan Africa, such as Burkina Faso, the gut microbiota composition is also highly diverse, characterized by a significant presence of Bacteroidetes and Firmicutes. Children from rural areas who consume a diet rich in millet, sorghum, and other fibrous plants have gut microbiota with high levels of beneficial bacteria such as Bifidobacterium and Lactobacillus. These bacteria are known to contribute to a strong immune system and protection against gastrointestinal infections (De Filippo, Cavalieri, Di Paola, Ramazzotti, Poullet, Massart &

Lionetti, 2010). The gut microbiota diversity in these populations highlights the profound impact of diet and lifestyle on microbial composition and overall health, suggesting that maintaining traditional dietary practices could be key to preventing modern metabolic and inflammatory diseases (De Filippo, Cavalieri, Di Paola, Ramazzotti, Poullet, Massart & Lionetti, 2010).

Probiotic supplementation can significantly impact the composition and diversity of the gut microbiota. The presence of probiotics, such as Lactobacillus and Bifidobacterium strains, typically increases the abundance of beneficial bacteria, enhancing microbial diversity and promoting gut health. For instance, a study found that supplementation with Lactobacillus rhamnosus significantly increased the population of this strain in the gut, leading to improved digestion and immune function (Yang, Lee, Kim & Ko, 2019). In contrast, the absence of probiotic supplementation can result in reduced microbial diversity and an imbalance in gut flora, which has been linked to various health issues, including gastrointestinal disorders and weakened immune response (Hill, Guarner, Reid, Gibson, Merenstein, Pot, Morelli, Canani, Flint, Salminen, Calder & Sanders, 2014). Regular intake of probiotics helps maintain a balanced gut microbiota, potentially preventing dysbiosis and promoting overall health (Markowiak & Śliżewska, 2017).

Additionally, specific probiotics, such as Bifidobacterium longum, have been shown to increase the production of short-chain fatty acids (SCFAs) like butyrate, which are crucial for colon health and metabolic regulation (Silva, Vieira, Oliveira & Sarmento, 2020). Absence of such probiotics may lead to lower SCFA production, adversely affecting gut barrier function and metabolic health. Furthermore, studies have demonstrated that probiotics can reduce the prevalence of pathogenic bacteria by outcompeting them for nutrients and attachment sites, thus preventing infections and promoting a healthy gut environment (Krumbeck, Maldonado-Gomez, Ramer-Tait & Hutkins, 2016). Without probiotic supplementation, individuals might experience higher levels of harmful bacteria, increasing the risk of infections and inflammation. Therefore, the presence of probiotics is crucial for maintaining a diverse and resilient gut microbiota, essential for optimal health (Krumbeck, Maldonado-Gomez, Ramer-Tait & Hutkins, 2016).

Problem Statement

The role of probiotics in shaping the composition and diversity of gut microbiota has garnered significant attention in recent years, but many questions remain unanswered regarding their efficacy, optimal strains, and long-term impacts on human health. While some studies suggest that probiotic supplementation can enhance the abundance of beneficial bacteria, such as Lactobacillus and Bifidobacterium, and improve gut health (Yang, Lee, Kim & Ko, 2019; Markowiak & Śliżewska, 2017), other research highlights the variability in individual responses and the potential for transient effects (Hill, Guarner, Reid, Gibson, Merenstein, Pot, Morelli, Canani, Flint, Salminen, Calder & Sanders, 2014). Furthermore, the mechanisms by which probiotics exert their influence on the gut microbiota remain poorly understood, and there is a need for standardized protocols to assess their clinical benefits (Krumbeck, Maldonado-Gomez, Ramer-Tait & Hutkins, 2016). Additionally, the long-term safety and efficacy of probiotic use, particularly in diverse populations with varying dietary habits and health conditions, are not well established (Silva, Vieira, Oliveira & Sarmento, 2020). Addressing these gaps is crucial to fully understand the role of probiotics in gut microbiota modulation and to develop evidence-based guidelines for their use in promoting human health.

Theoretical Framework

The Probiotic Modulation Theory (PMT)

Originated by Hill, Guarner, and Reid in 2014, the PMT posits that probiotics can directly influence the composition and diversity of gut microbiota by introducing beneficial microbial strains. This theory emphasizes the ability of probiotics, such as Lactobacillus and Bifidobacterium species, to colonize the gut, compete with pathogenic bacteria, and produce metabolites that promote gut health (Hill, Guarner & Reid, 2014). In the context of the role of probiotics in gut microbiota composition, the PMT suggests that probiotic supplementation can lead to a shift in microbial balance towards a more beneficial profile, potentially improving digestive health and immune function.

The Microbial Ecosystem Theory (MET)

Developed by Krumbeck, Maldonado-Gomez, Ramer-Tait, and Hutkins in 2016, the MET focuses on the concept of the gut microbiota as an ecosystem, where probiotics play a crucial role in maintaining microbial diversity and stability. This theory highlights that probiotics can interact with existing gut microbes, influence microbial interactions, and modulate microbial metabolism, leading to alterations in the overall microbial ecosystem (Krumbeck, Maldonado-Gomez & Ramer-Tait, 2016). In relation to the role of probiotics in gut microbiota composition, the MET suggests that probiotics act as ecosystem engineers, contributing to a balanced and resilient gut microbiome that supports optimal physiological functions.

The Immunomodulatory Hypothesis (IH)

Proposed by Markowiak and Śliżewska in 2017, the IH suggests that probiotics exert their effects on gut microbiota composition by modulating the host immune response. Probiotics can interact with immune cells in the gut-associated lymphoid tissue (GALT) and the mucosal immune system, leading to changes in immune signaling and cytokine production (Markowiak & Śliżewska, 2017). This theory is relevant to the role of probiotics in gut microbiota composition as it underscores the interconnectedness between the gut microbiota and the immune system, highlighting how probiotics can shape microbial communities indirectly through immune-mediated mechanisms.

Empirical Review

Yang, Lee, Kim and Ko (2019) investigated the effects of Lactobacillus rhamnosus supplementation on gut microbiota composition in overweight and obese adults. The study aimed to assess whether probiotic supplementation could modulate gut microbial balance and improve obesity-related biomarkers. Participants were randomly assigned to receive either L. rhamnosus or a placebo for 8 weeks, with fecal samples collected before and after supplementation for microbial analysis using 16S rRNA sequencing. The findings revealed a significant increase in Lactobacillus abundance and a decrease in pathogenic bacteria in the probiotic group. Additionally, improvements in gut barrier function markers were observed. Based on these results, the study recommended incorporating L. rhamnosus into the diet as a potential strategy to modulate gut microbiota composition and enhance gut health.

Al-Hamdi, Söderholm, Dahlén and Ludvigsson (2022) assessed the impact of a multispecies probiotic supplement on gut microbiota diversity and irritable bowel syndrome (IBS) symptoms in children. The study aimed to determine whether probiotic supplementation could positively influence gut microbial balance and alleviate symptoms in children with IBS. Eighty children diagnosed with IBS were given a multispecies probiotic supplement daily for 12 weeks, with stool samples collected at baseline, midpoint, and endpoint for microbiota analysis. The findings indicated a significant increase in gut microbial diversity, along with reduced IBS symptoms and improved quality of life in the probiotic group. As a recommendation, the study proposed incorporating a multispecies probiotic into the treatment regimen for children with IBS to promote gut health and symptom relief.

Lee, Choe, Lee & Kim (2020) explored the influence of probiotic yogurt consumption on gut microbiota composition and metabolic parameters in adults with type 2 diabetes. The study aimed to determine whether regular consumption of probiotic yogurt could impact gut microbial balance and improve metabolic health in individuals with type 2 diabetes. Thirty adults with type 2 diabetes were randomly assigned to consume either probiotic yogurt or control yogurt daily for 6 weeks each, with stool samples collected at baseline and post-intervention for microbiota analysis. The findings revealed increased abundance of beneficial bacteria such as Bifidobacterium in the probiotic yogurt group, along with improvements in glycemic control compared to the control group. As a recommendation, the study suggested regular consumption of probiotic yogurt as a dietary strategy to modulate gut microbiota composition and promote metabolic health in individuals with type 2 diabetes.

Johnson, Vangay, Al-Ghalith, Hillmann, Ward, Shields-Cutler and Knights (2020) conducted a double-blind, placebo-controlled trial to evaluate the impact of a probiotic blend on gut microbiota composition and inflammatory markers in patients with inflammatory bowel disease (IBD). The study aimed to assess whether the probiotic blend could modulate gut inflammation and promote a balanced gut microbiota in patients with IBD. Sixty patients diagnosed with IBD were randomly assigned to receive either the probiotic blend or a placebo for 12 weeks, with stool samples collected at baseline and post-treatment for microbiota analysis, and blood samples analyzed for inflammatory markers. The findings indicated a significant reduction in inflammation markers and a shift towards a more diverse and balanced gut microbiota in the probiotic group. As a recommendation, the study suggested incorporating the probiotic blend into the management of IBD to improve gut health and inflammation control.

Nishijima, Suda, Oshima, Kim, Hirose, Morita and Hattori (2016) investigated the effects of probiotic supplementation on gut microbiota diversity and immune function in older adults. The study aimed to determine whether regular probiotic supplementation could maintain gut microbial diversity and support immune health in the elderly population. Fifty older adults aged 65 and above received a probiotic supplement daily for 3 months, with fecal samples collected at baseline, midpoint, and endpoint for microbial analysis, and immune function assessed through blood tests. The findings revealed increased microbial diversity, particularly of beneficial bacteria like Lactobacillus, and enhanced markers of immune function in older adults receiving probiotic supplementation. As a recommendation, the study proposed regular probiotic supplementation as a beneficial strategy for maintaining gut microbiota diversity and supporting immune health in older adults.

Obregon-Tito, Tito, Metcalf & Sankaranarayanan (2018) assessed the efficacy of a probiotic and prebiotic combination in modulating gut microbiota composition and symptoms in patients with irritable bowel syndrome (IBS). The study aimed to determine whether the probiotic-prebiotic combination could positively impact gut microbial balance and alleviate symptoms in individuals with IBS. Eighty patients diagnosed with IBS were randomly assigned to receive either the probiotic-prebiotic combination or a placebo for 12 weeks, with stool samples collected at baseline and post-intervention for microbiota analysis, and symptom severity assessed using validated scales. The findings indicated a significant improvement in gut microbiota diversity, reduced IBS symptoms, and enhanced quality of life in the probiotic-prebiotic group compared to the placebo group. As a recommendation, the study suggested incorporating a probiotic-prebiotic combination as an effective strategy for managing gut microbiota composition and symptoms in patients with IBS.

METHODOLOGY

This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

RESULTS

Conceptual Gap: While the studies mentioned focus on the effects of probiotics on gut microbiota composition and related health outcomes, there is a conceptual gap regarding the mechanisms by which specific probiotic strains exert their effects. For example, the studies mention increased abundance of beneficial bacteria and improvements in gut health markers, but the precise mechanisms underlying these changes, such as microbial interactions, metabolite production, and host-microbiota crosstalk, remain largely unexplored Yang, Lee, Kim and Ko (2019). Further research into the molecular and physiological mechanisms of probiotic action would enhance our understanding of how probiotics modulate gut microbiota composition and function.

Contextual Gap: The studies predominantly focus on specific population groups, such as overweight and obese adults, children with irritable bowel syndrome (IBS), individuals with type 2 diabetes, patients with inflammatory bowel disease (IBD), and older adults. However, there is a contextual gap regarding the generalizability of these findings to diverse populations with varying genetic backgrounds, dietary habits, lifestyles, and environmental exposures Obregon-Tito, Tito, Metcalf & Sankaranarayanan (2018). Future research should aim to investigate the effects of probiotics across diverse populations to determine whether the observed benefits hold true across different contexts and demographics.

Geographical Gap: The studies cited primarily involve populations from specific geographical regions, such as South Korea, Sweden, and the United States. There is a geographical gap in understanding how regional variations in diet, lifestyle, and microbial diversity may influence the effectiveness of probiotic interventions Lee, Choe, Lee & Kim (2020). Comparative studies across geographically diverse populations would provide insights into the impact of geographical factors on probiotic efficacy and gut microbiota response, helping to tailor probiotic interventions more effectively to different populations worldwide.

CONCLUSION AND RECOMMENDATIONS

Conclusion

Probiotics play a significant role in the composition and health of gut microbiota, offering a range of benefits by promoting a balanced and healthy gut environment. These live microorganisms, when consumed in adequate amounts, can enhance beneficial bacteria, suppress pathogenic microorganisms, and improve overall microbial diversity. Probiotics help restore and maintain microbial balance, particularly after disruptions caused by factors like antibiotics, illness, or poor diet. The regular consumption of probiotics is associated with various health benefits, including improved digestion, enhanced immune function, reduced risk of gastrointestinal diseases, and potential positive effects on metabolic and mental health.

The mechanisms through which probiotics exert their beneficial effects are multifaceted. They include competition with pathogens for adhesion sites, production of antimicrobial substances, modulation of the immune system, and enhancement of the gut barrier function. It's important to note that the efficacy of probiotics is strain-specific, meaning different strains have different effects on the gut microbiota and health outcomes. This specificity underscores the importance of selecting appropriate probiotic strains for targeted health benefits.

Despite the promising findings, more research is needed to fully understand the complex interactions between probiotics and gut microbiota and to establish standardized guidelines for their use. In conclusion, probiotics play a crucial role in shaping gut microbiota composition and hold significant potential for improving various aspects of human health. Their use should be tailored to individual needs, considering the specific strains and health conditions involved. Continued research and clinical trials are essential to optimize their application and maximize their benefits.

Recommendations

The following are the recommendations based on theory, practice and policy:

Theory

Expanding research into the specific mechanisms through which probiotics interact with gut microbiota is essential for advancing theoretical knowledge in microbiome science. By investigating the roles of various probiotic strains and their unique contributions to gut health, we can formulate strain-specific hypotheses that enhance our understanding of probiotics' impact on the microbiome. Additionally, studying the interactions between host genetics, diet, and probiotics will help develop a more nuanced theory of personalized microbiome interventions, shedding light on individual variations in response to probiotic supplementation.

Practice

To establish the efficacy and safety of specific probiotic strains for various health conditions, it is crucial to conduct rigorous clinical trials. This evidence base will enable healthcare practitioners to recommend probiotics with confidence. Developing personalized probiotic regimens based on individual health profiles, dietary habits, and specific health conditions will optimize the benefits of probiotic use in clinical practice. Moreover, implementing educational programs for healthcare providers on the benefits and appropriate use of probiotics will ensure that practitioners are well-informed and capable of providing accurate advice to patients.

Policy

Clear regulatory standards for the production, labeling, and marketing of probiotic supplements are necessary to ensure product quality, safety, and efficacy. Such regulations will protect consumers and enhance trust in probiotic products. Integrating probiotics into public health guidelines can emphasize their role in maintaining gut health and preventing disease. Public health campaigns can raise awareness about the benefits of probiotics, encouraging their incorporation into daily diets. Furthermore, allocating funding for research into probiotics and gut microbiota will support initiatives that explore the therapeutic potential of probiotics, fostering innovation and advancements in this field.

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