ISSN No:-2456-2165

The Effects of Prebiotics on Gut Microbiota Composition and Diversity in Healthy Individuals

Janvi Yadav [1], Anindita Ghosh [2]
Department of Nutritional sciences and Dietetics,
Symbiosis Skills and Professional University, Pune

Abstract:- A literature review of the literature has been conducted. With the goal of thoroughly examining and tying all the studies already done on the impact of prebiotics on the diversity and composition of the gut microbiota in healthy people. 25 articles were selected for the research project. In accordance with the inclusion and exclusion criteria given. The method involved a methodical process of searching, choosing, extracting data, and synthesizing it. The findings of this research provide important information about how prebiotics affect the variety and composition of the gut microbiota in healthy individuals. The proband prebiotic principles are based on the modification of gut microbiota via dietary methods. Prebiotics encourage the growth or activities of specific bacterial genera and species in the gut microbiota in order to boost the host's health. When certain food products with a prebiotic effect have been employed, preliminary studies have indicated encouraging beneficial outcomes, including changes in the composition of the gut flora.

Keywords:- *Prebiotics, Gut Microbes, Microbiota, Gut Bacteria, Human Gut, Gastrointestinal Tract, Gut Flora, Colonic Fermentation, Microbiome, Prebiotic Concept, Microbial Diversity, Microbial Composition*

I. INTRODUCTION

Prebiotics are non-digestible food items that have positive effects on the host by encouraging the growth of a small number of bacteria there. Prebiotics are a family of dietary compounds that are characterized by their ability to promote the activity and growth of bacteria in the gastrointestinal flora, hence improving host health(Akanksha Nirmal,2022). Incorporating prebiotics into a daily diet promotes specialized bacterial growth and functionality, which modifies the gut microorganisms. Prebiotics are fermented by the controlled microorganisms into short chain fatty acids, which have a number of positive health effects(Ashwini priyadarshini, 2022). Prebiotics are consumed to regulate gut flora, which creates SCFAs that are good for lowering blood sugar, reducing inflammation, and other things. Food is regarded as the primary substrate that greatly influences the makeup of microorganisms and contributes to their proliferation(De Angelus, Garruti,2019). Prebiotics in the diet may have the ability to influence the composition of the host's microbial community in a way that will benefit the host's overall health and well-being(Vallianou, Davani-Davani,2019).

Prebiotics were administered in an experiment, and the results revealed certain specific alterations in the microbial makeup(Denji,2016). Collective data from experiments using animal models and human research has shown that these factors alter the variety of healthpromoting microorganisms like Lactobacilli and Bifidobacteria in the gastrointestinal tract. The promotion of microbial activity and growth has positive effects on health and wellbeing(Daiva Baltriukiene,2022). According to research done in specified pure culture fermentation, when inulin supplementation is given to 10 women for 19 days, the amount of Bifidobacteria in the gut microbiota considerably increases. It has been demonstrated that inulin, also known as fructans, selectively stimulates bacterial growth(Kleesen, Sykura,2020). By creating a significant amount of butyrate, resistant starch supports the health benefits. Asparagus, sugarbeet, garlic, chicory, onion, artichoke, wheat, honey, banana, legumes, barley, tomato, rye, soybean, milk, peas, beans, seaweeds, etc. are only a few examples of the foods that naturally contain them. The ecosystem of the human intestine can be entirely altered by prebiotics. Because prebiotics' fermentation products are acids, they change the pH of the gut and affect the composition of the gut microbiota(Dorna Davani-Davani,2019). A diet high in prebiotics, particularly inulin, oligosaccharides, and oligofructose, has also been shown to support the growth of lactobacilli and bifidobacteria in the gut microbiota. As was already said, prebiotics are fermented by bacteria to form SCFAs, which affect cellular processes by activating G protein-coupled receptors and lowering pH, both of which prevent pathogenic bacteria from growing.

According to studies, prebiotics can be regularly consumed to sustain the favorable alterations in the microbiome. Native microorganisms, including some species' development and enzymatic activity, are entirely responsible for the microbial diversity in an environment(Alma Cruz,2021). Resistance starch and the raffinose family of oligosaccharides are examples of prebiotic carbohydrates that support bacterial growth(Sangam Dwivedi,2014). According to the study by Gibson et al., consumption of oligofructose or inulin raised the proportion of Bifidobacterium, demonstrating the impact of prebiotics on intestinal flora(Shumin Wang,2020).

A. Prebiotics' mode of action

Prebiotics can alter the composition of the bacteria in the gut, and they can also help the host by changing the environment in the gut through interactions with the bacteria that live on intestinal epithelial cells, possible pathogens, and the immune system.

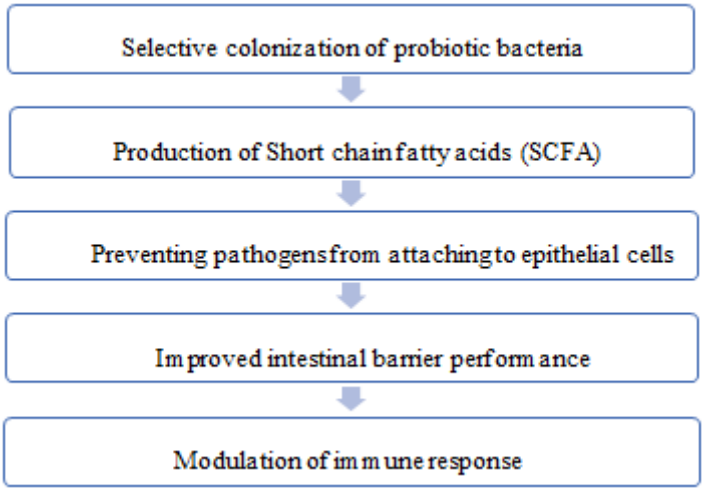

Fig 1 Prebiotics' mode of action

Figure illustrating Prebiotics' mode of action.. Prebiotics' impact is thus displayed: (1) Bifidobacteria and lactobacilli are specifically colonized as a result of competition with pathogenic strains for prebiotics. (2) The pH is lowered as a result of the production of short-chain fatty acids (SCFA), including acetate, propionate, and butyrate. (3) Preventing pathogens from attaching to epithelial cells. (4) Increased mucus results in improved intestinal barrier performance. (5) Immune response modulation.

Figure 1, summarizes the mechanism of action of prebiotics. Immune cell carbon hydrate receptors are affected by prebiotics. Betaglucans cause the phagocytosis of neutrophils by binding to receptors on phagocytes and natural killer cells. Because they serve as receptors for bacterial or viral adhesion molecules and are absorbed from the GI tract into the gastrointestinal system, human milk oligosaccharides (HMOs) have antibacterial and antiviral properties. The gut microbiota's ability to break down indigestible carbohydrates that pass through the distal intestine intact is made possible by the presence of polysaccharide lyases and glycoside hydrolases. The fermentation of these prebiotics produces SCFAs, which can cross the colon and affect the immune system. Acetate, propionate, and butyrate are SCFAs that exhibit antibacterial activity and reduce the pH in the stomach. Prebiotics also selectively boost or decrease certain intestinal bacteria that may be beneficial to health(Fatima Enam,2019).

The species in the intestine can be clearly and permanently upregulated by prebiotics. We will be able to make more informed judgments about how to change the microbiota for the better by understanding the biology of prebiotics and how they relate to the dynamics of the gut microbiome.

II. METHODOLOGY

A. Information Search Strategies

For all of the publications that were available, searches were done using the search phrases in Google Scholar, Pubmed, Research Gate, Science Direct, and Open Access publications. Published between 2017 and 2022.Any studies missed by the database search were looked for in the reference lists of earlier evaluations. Conferencing presentations, reviews, unpublished dissertations or theses, or any other publications (such as government studies or market research) that were not published in peer-reviewed journals, were excluded due to a lack of thorough peer assessment. Relevance was checked on article titles. A total of 25 pertinent research articles were found and included in the review of the literature. The literature search, article screening, and data extraction were all completed by the first author. The papers that met the inclusion criteria as well as the data they contained were examined by both authors.

B. Inclusion Criteria

We only included articles in our search that met the following criteria:

- Genuine and authentic research papers.
- Studies examining the benefits of prebiotics on gut health.
- Surveys and trails proving that prebiotics effects on the gut microbiota composition.
- Journals comprising of articles which shows clear view that prebiotics effects the microbial diversity in healthy individuals.
- Journals with peer review 6) Articles available on the Authentic journals with clear understanding of concept and language.

Studies were considered if they examined the diversity and composition of the gut microbiota in relation to prebiotics. According to more recent definitions of prebiotics, after being processed by gut bacteria, they have a positive physiological effect on the host by altering the composition or activity of the gut microbiota. Additionally, scientific definitions that have been updated to reflect developments in the field have helped us comprehend and appreciate the significance of prebiotics for the health of the overall gut microbiota.(as shown in Table No.1).

Table 1 : Inclusion and Exclusion Table

Source	Inclusion	Exclusion
Google scholar	101 papers were shown, of which 11 were selected for review, suitable as per topic	Others were about diseases, food allergies, mental disorders, maternal womens, etc.
Pubmed	559 results were shown of which 15 were selected for review	Papers on pediatrics, infants, overweight and obese individuals were excluded.
Research gate	200 results were shown of which 20 were relevant to topic	Others were about diseases, fermentation by probiotics, gut- brain axis and trials on disease individuals
Science direct	250 results were shown of which research papers based on effect of prebiotic on microbial diversity and composition on healthy individuals were selected	Excluded ones were about diseases, infants, trials on obese and diabetic individuals,etc.

C. Method of Analysis

This review of the literature gives a narrative summary of the studies that met the inclusion criteria. The foundation of prebiotic notions is the dietary manipulation of gut microbiota. The prebiotics' mode of action is displayed, demonstrating how significantly they affect the metabolism of the host. Prebiotics have the ability to hasten the opportunistic growth of advantageous members, so enhancing the host's gut flora.

III. RESULT

The review includes a total of 25 research articles that satisfied the inclusion requirements. These studies include a variety of designs, although the majority are cross-sectional or case-control studies. Small groups to extensive population studies comprise a range of sample sizes. Prebiotics have the ability to increase the opportunity for helpful microbial members while decreasing the number of detrimental members in the gut microbiome, according to studies in general. A healthier variety of bacteria is produced as a result, which enhances the host microbiota.

According to recent studies, diets containing prebiotics can be used to modulate the gut microbiota while maintaining a healthy gut environment and variety. Prebiotics also have an impact on the immune system, lowering the risk of immunological illnesses and boosting the activity of natural killer (NK) cells, according to a number of studies. In reality, the importance of the gut microbiota as a substantial organ separate from the rest of the body and essential to human health is becoming more widely recognized. The bacteria Bifidobacterium spp. And Lactobacillus spp. Are therefore thought to be present in larger concentrations in healthy people who consume prebiotics. In their gut flora. Additionally, some scientists contend that consuming prebiotics does not always result in a global alteration in the variety of gut microorganisms. Modification is, however, largely seen in bacterial taxa like Parabacteroides and Ruminococcaceae.

It was successful in achieving the review's goal of educating readers on the value of the host's gut flora. Prebiotic consumption has a direct impact on how diverse and composed the gut microbiota is in healthy people.

IV. DISCUSSION

Beyond microbial growth, the regulation of colonic microbial to a healthy condition is anticipated to become an important and developing target for prebiotics. With pathogens excluded, a new area of research is pathogens' capacity to regulate bacterial development. Prebiotics have certain known health advantages, some of which led to changes in the microbiota such an increase in SCFAs. Future microbiome regulation, especially its impact on the diversity and composition of gut bacteria, will heavily depend on the prebiotic scope.

Following the metagonic investigation, it is learned that prebiotics have an effect on the entire composition of gut flora(Alma Cruz, 2021)(As shown in Table No. 2).

Table 2 : The impact of Prebiotics on Gut bacteria

Prebiotic	Model information	Impact on gut bacteria
Galacto-Oligosaccharides (GOS)	Galacto-oligosaccharides (GOS) were given to a group of healthy adult volunteers, dose of 2.4 g	Bifidobacterium and Lactobacillus are now more prevalent.
Bovine milk-Oligosaccharides (BMO)	Effects of BMO and lactose coculture on Bifidobacterium longum subsp. Longum metabolism and suppression of Clostridium perfringens	Reduce Clostridium perfringens and raise Bifidobacterium
B- glucans	2 months of daily 3g barley beta-glucan administration to healthy human subjects	Firmicutes and fusubacterium concentrations decreased, but the concentrations of Prevotella, Roseburia, and Clostridium increased.
Resistant starch type 3	Prebiotic diet percentage was raised by 20% increments until it reached 100%	Prevotella, Ruminococcus, and Lachnospiraceae prevalence is rising
Resistant starch type 4	Metabolic syndrome patients 26 weeks of treatment, including a two- to twelveweek intervention period	Bacteroides and Parabacteroides species are mostly increasing.

In several investigations, fructans were shown to be able to specifically promote lactic acid bacteria. In a randomized trial, prebiotics like 4 grams of GOS in juice were consumed twice daily for three weeks to study the effects of GOS. It was found that supplementing with GOS had a bifidogenic effect and increased the number of bifidobacteria. The production of the byproduct of bacterial fermentation known as butyrate was also seen to be rising.

In the other trial, fructooligosaccharides were used, and GOS results revealed a rise in bifidobacteria and a fall in harmful bacteria. A study on the effects of inulin supplementation on 10 healthy women over the course of 19 days reveals a notable rise in the bifidobacteria that make up the gut flora. Furthermore, research on both humans and animals has demonstrated that prebiotics can reduce the number of dangerous Lactobacilli and bifidobacteria. According to clinical investigations, prebiotics can also have an impact on the immune system(Dorna Davani-Davani,2019). Adults between the ages of 45 and 63 who get 8 g/day of FSO for 8 weeks exhibit an increased immunological response. NK cell activity was elevated in the elderly individuals who took 5.5 g/day of GOS for 10 weeks.

V. CONCLUSION

This review of the literature demonstrates that the entire composition of gut microbes is affected by prebiotics, according to the results of the metagonic analysis. The studies also imply that prebiotics can be regularly consumed to maintain beneficial changes in the microbiome. Prebiotics increase the growth of Bifidobacteria, Lactobacilli, and SCFAs, which have an impact on cellular mechanisms and activate G protein coupled receptors, which results in a decrease in pH, which encourages the growth of the gastrointestinal microbiome and prevents or slows the spread of harmful microorganisms.

An earlier definition of the term “prebiotics” was “a non-digestible food ingredient that benefits the host by promoting the growth and activity of microbes in the gut and thereby improves host health.”

Later, this definition was amended to “selectively fermented ingredient” in order to allow for beneficial changes in the composition and activity of the GI microflora.

A new definition of “prebiotics” is now being developed to better represent the changes in our knowledge and appreciation of the significance of gut flora as a whole. Recent definitions have advocated for a broader perspective.

REFERENCES

[1]. Olvera-Rosales, L.-B.;Cruz-Guerrero, A.-E.;Ramírez-Moreno, E.; Quintero-Lira,A.; Contreras-López, E.;Jaimez-Ordaz, J.; Castañeda- Ovando,A.; Añorve-Morga, J.;Calderón-Ramos, Z.-G.; Arias-Rico. Impact of the Gut MicrobiotaBalance on the Health–DiseaseRelationship: The Importance ofConsuming Probiotics and Prebiotics.Foods **2021**,10, 1261

[2]. Ashwini priyadarshini Megur, Eric Banon- Meine Dalini, Daiva Baltriukiene, Aurelijus Burokas. Prebiotics as a Tool for Prevention and Treatment of Obesity and Diabetes: Classification and ability to Modulate the Gut Microbiota, Int. J. Mol. Sci. **2022**, 23(11), 6097; https://doi.org/10.3390/ijms23116097

[3]. Carlson JL, Erickson JM, Lloyd BB, Slavin JL. Health Effects and Sources of Prebiotic Dietary Fiber. Curr Dev Nutr. **2018** Jan 29;2(3):nzy005. Doi: 10.1093/cdn/nzy005. PMID: 30019028; PMCID: PMC6041804.

[4]. Justin L Carlson, Jennifer M Erickson, Beate B Lloyd, Joanne L Slavin. Health benefits and sources of Prebiotic Dietary Fiber. **2018** Mar;2(3): nzy005. Published online 2018 Jan 29. Doi: 10.1093/cdn/nzy005, PMCID: PMC6041804PMID: 30019028

[5]. Price T Edwards, Purna C Kashyap, Geoffrey A. Preidis. Microbiota on Biotics: Probiotics, prebiotics,and synbiotics to optimize growth and metabolism. AJP-Gastrointest Liver Physiol • doi:10.1152/ajpgi.00028.**2020** • www.ajpgi.org

[6]. Davani-Davari D, Negahdaripour M, Karimzadeh I, Seifan M, Mohkam M, Masoumi SJ, Berenjian A, Ghasemi Y. Prebiotics: Definition, Types, Sources, Mechanisms, and Clinical Applications. Foods. **2019** Mar 9;8(3):92. Doi: 10.3390/foods8030092. PMID: 30857316; PMCID: PMC6463098.

[7]. Akanksha K. Nirmal, Poonam V. Gadekar, Gajanan S Sanap. Role of Prebiotics and probiotics in gastrointestinal disease, International Journal of Creative Research Thoughts(IJCRT).**2022** https://ijcrt.org/papers/IJCRT2202275.pdf

[8]. Edwards PT, Kashyap PC, Preidis GA. Microbiota on biotics: probiotics,Prebiotics, and synbiotics to optimize growth and metabolism. Am J Physiol Gastrointest Liver Physiol 319: G382–G390, **2020**. First published August 5, 2020;Doi:10.1152/ajpgi.00028.2020.

[9]. Sangam Dwivedi, Kanwar Sahrawat, Naveen Puppala, Rodomiro Ortiz. Plant prebiotics and Human Health: Biotechnology to breed prebiotic- rich nutritious food crops, Electronic Journal of Biotechnology.,**2014**, 238 245;https://doi.org/10.1016/j.ejbt.2014.07.004 10.

[10]. Umu ÖCO, Rudi K, Diep DB. Modulation of the gut microbiota by prebiotic fibres and bacteriocins. Microb Ecol Health Dis. **2017** Jan 1;28(1):1348886. doi: 10.1080/16512235.2017.1348886. PMID: 28959178; PMCID: PMC5614387.

[11]. Fatima Enam, Thomas J. Manshell. Prebiotics: tool to manipulate the gut microbiome and metabolism, Journal of Industrial Microbiology & Biotechnology (**2019**) 46:1445–1459; https://doi.org/10.1007/s10295-019-02203-4

[12]. Roberfroid, M., Gibson, G., Hoyles, L., McCartney, A., Rastall, R., Rowland, I., . . . Meheust, A. (**2016**). Prebiotic effects: Metabolic and health benefits. British Journal of Nutrition, 104(S2), S1-S63. Doi:10.1017/S0007114510003363; https://doi.org/10.1017/S0007114510003363

[13]. Shumin Wang, Yue Xiao, Fengwei Tian, Jianxin Zhao, Hao Zhang, Qixiao Zhai, Wei Chen.Rational use of prebiotics for gut microbiota alterations:Specific bacterial phylotypes and related mechanisms,Journal of Functional Foods,Volume 66,**2020**,103838,ISSN 1756-4646 https://www.sciencedirect.com/science/article/pii/S1756464620300621?via%3Dihub

[14]. Bedu-Ferrari C, Biscarrat P, Langella P, Cherbuy C. Prebiotics and the Human Gut Microbiota: From Breakdown Mechanisms to the Impact on Metabolic Health. Nutrients. **2022** May 17;14(10):2096. doi: 10.3390/nu14102096. PMID: 35631237; PMCID: PMC9147914.

[15]. Marla Cunningham, M. Andra Azcarate- Peril, Apan Barnard, Valerie Benoit, Roberta Grimaldi, Denis Guyonnet, Hannah D. Holscher, Kinsty hunter. Shaping the Future of Prebiotics and Probiotics, Cell press journal on Trends in Microbiology. **2021**,Volume 29, Issue 8, P667- 685; https://doi.org/10.1016/j.tim.2021.01.003

[16]. Tsai, YL., Lin, TL., Chang, CJ. Et al. Probiotics, prebiotics and amelioration of diseases. J Biomed Sci 26, 3 (**2019**). https://doi.org/10.1186/s12929-018-0493-6

[17]. Delzenne NM, Neyrinck AM, Bäckhed F, Cani PD. Targeting gut microbiota in obesity: effects of prebiotics and probiotics. Nat Rev Endocrinol. 2011 Aug 9;7(11):639-46. Doi: 10.1038/nrendo.2011.126. PMID: 21826100.

[18]. Nogacka AM, Salazar N, Arboleya S, Ruas-Madiedo P, Mancabelli L, Suarez A, Martinez-Faedo C, Ventura M, Tochio T, Hirano K, Endo A, G de Los Reyes-Gavilán C, Gueimonde M. In Vitro Evaluation of Different Prebiotics on the Modulation of Gut Microbiota Composition and Function in Morbid Obese and Normal-Weight Subjects. Int J Mol Sci. **2020** Jan 30;21(3):906. Doi: 10.3390/ijms21030906. PMID: 32019174; PMCID: PMC7038051.

[19]. Sánchez y Sánchez de la Barquera, B., Martínez Carrillo, B.E., Aguirre Garrido, J.F. et al. Emerging Evidence on the Use of Probiotics and Prebiotics to Improve the Gut Microbiota of Older Adults with Frailty Syndrome: A Narrative Review. J Nutr Health Aging 26, 926–935 (**2022**). https://doi.org/10.1007/s12603-022-1842-4

[20]. Rivera-Piza, A., Lee, SJ. Effects of dietary fibers and prebiotics in adiposity regulation via modulation of gut microbiota. Appl Biol Chem 63, 2 (**2020**). https://doi.org/10.1186/s13765-019-0482-9

[21]. Holmes, Z.C., Villa, M.M., Durand, H.K. et al. Microbiota responses to different prebiotics are conserved within individuals and associated with habitual fiber intake. Microbiome 10, 114 (**2022**). https://doi.org/10.1186/s40168-022-01307-x

[22]. Holscher HD. Dietary fiber and prebiotics and the gastrointestinal microbiota. Gut Microbes. **2017** Mar 4;8(2):172-184. Doi: 10.1080/19490976.2017.1290756. Epub 2017 Feb 6. PMID: 28165863; PMCID: PMC5390821.

[23]. Davani-Davari D, Negahdaripour M, Karimzadeh I, Seifan M, Mohkam M, Masoumi SJ, Berenjian A, Ghasemi Y. Prebiotics: Definition, Types, Sources, Mechanisms, and Clinical Applications. Foods. 2019 Mar 9;8(3):92. doi:10.3390/foods8030092.PMID:30857316;PMCID: PMC6463098. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6463098/#:~:text=Animal%20and%20human%20studies%20have,promoting%20mannose%20adhesion%20to%20Salmonella