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Probiotic and Prebiotics – A Review

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Abstract

Probiotics are food supplements that contain live microorganisms fostered growth population of beneficial bacteria (normal microflora) in the host gut. Prebiotics are non-digestible fiber compounds of foods that help growth the beneficial human microflora in the colon. Probiotics are used for conserving or restoring the balance of these gut flora.

Some dietary sources of probiotics include Sauer kraut and yogurt. While, dietary non-digestible carbohydrates (prebiotics) include unrefined wheat and barley, raw oats, soya beans, Jerusalem artichoke, garlic and onion. Both probiotics and prebiotics are functional food supplements and they are available as salutary supplements. The research in this field are ongoing into the relationship of these supplements and gastrointestinal micro flora leading to illness. Using Probiotics and Prebiotics together, known as symbiotic and may have synergistic effects that enhancing their individual benefits. This combination can create a good favorable media for gastrointestinal microbiota and improved gut health.

This review's goal is to highlight the beneficial health effects of both pro and prebiotics, as well as their hidden effects. It will also discuss the many kinds of probiotics and prebiotic and how they work.

Introduction

Since the turn of the twenty-first century, there has been increasing research interest about flora's health. The intestinal micro flora is more numerous and complicated than the symbiotic flora present in other human body passages. 10^{14} cfu\ bacteria, or (the most number of eukaryotic bacteria within human body, are found in the human microbiota) **Wang *et al*., (2016).**

Beneficial microflora of the gut provids the body's systemic physiological conditioning and helps the host absorb nutrients from meals, two processes that are directly related to human health.

The gut flora could be categorized in to three

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functional categories according to their effects on the host body: probiotics; harmless bacteria and harmful bacteria **Jones *et al*., (2007).** These compete and constrain one another in healthy individuals, preserving a typical dynamic equilibrium.

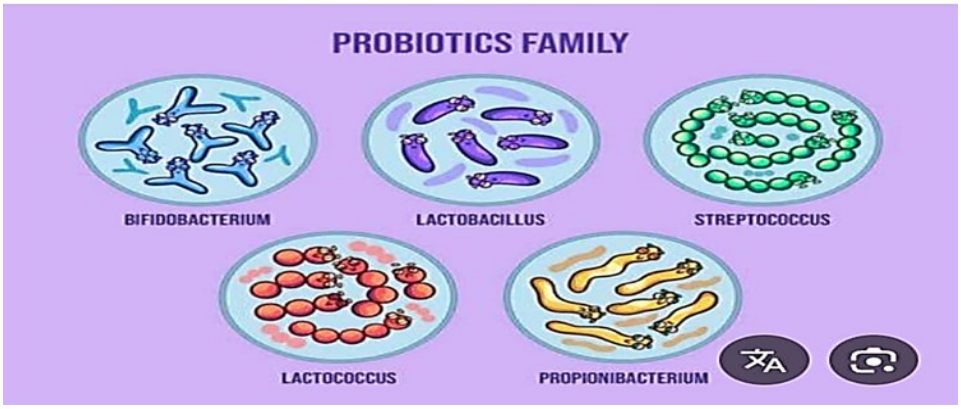
Body health is influenced by the integrity of the digestive tract that has been recognized as the second human body's brain. Interactions between intestinal microbiota and human body induce the production of functional materials required for life, such as amino acids, short chain fatty acids, vitamins, etc., additionally, digestion and nutrients absorption from digested food and the metabolism of toxic waste produced in the digestive tract, (**Lian *et al*., 2022; Dial *et al*., 2022).** Maintenance of intestinal microbiome homeostasis is very important since any disruption can lead to gut dysbiosis and negatively impact individual health leading to increase diseases susceptibility like diarrhea, obesity, diabetes, and colon cancer **(Gao *et al*., 2018; Huang *et al*., 2022 and Yan *et al*., 2022).** Therefore, to keep microflora of the gut in an equilibrium condition, the quantity of probiotics and harmful bacteria needs to be regulated by an external factor. Given the benefits of probiotics, we require to know its positive effects inside the human body, and improve its proliferation and activity. Benefits improvement of probiotics depends on the selectively stimulating growth effect by prebiotics. Prebiotics are mostly fibers with selective fermenting component (mainly polysaccharides) that can stimulant healthy proliferation of gut microbiome **Li *et al*., (2021).**

Overview of probiotics

WHO and FDA defined probiotics as "a live active microorganisms strains that have undergone extensive screening and, when properly consumed, can improve a person's health" **Markowia and Slizewska, (2018).** Probiotics can help the human body in many ways, such as alleviating and treating lactose intolerance, regulating gastrointestinal health, maintaining of intestinal microbial balance, modulating human's immune functions, increasing digestion and nutrient absorption, enhancing blood sugar metabolism, and improving blood lipids **Lafata *et al*., (2018); Cho and Kim, (2015); Oak and Tha, (2019)**. Probiotics should assess the ability to proliferate in the food products and endure in adequate quantities till they arrive at their terminus in order to provide positive health effects. Thus, it is evident that the probiotics' adherence to enterocytes of intestinal mucosa must be taken into account while choosing them, **Shewale *et al*., (2014) and Sanchez, (2017)**.

Probiotics work on the body in a number of ways:

1- Preventing possible infections and stopping their spread.
2- Fighting against pathogenic invasion while vying for nutrition and space.
3- Enhancement of the gut's barrier function.
4- Immune control of the body by reducing antibody response, phagocytosis, and inflammation.
5- The host can be modulated by the synthesis of neurotransmitters.
6- Production of organic acid to lower intestinal PH.



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Types of probiotics

1. Lactobacillus

Nowadays, most probiotic research focuses on Lactobacillus bacteria because they are the most demonstrative of the "lactic acid producing bacteria (LAB)". Some of the important properties of Lactobacillus in enhancing host gut microbiome, which is directly influence on host's health. By suppressing the growth of harmful pathogens and producing essential vitamins and amino acids, it can enhance intestinal microecology **Milani *et al*., (2017)**. Controlling the *Escherichia coli* population in the intestine can be achieved by enhancement the growth and proliferation of lactobacillus, which is also carried out by Short Chain Fatty Acids (SCFAs), an essential metabolic product of lactobacillus. This maintains the typical physiological function of colon and healthy integrity of intestinal epithelium **Ding *et al*., (2019).** Lactobacillus greatly accelerates host growth, by enhancing host's growth performance and gain weight. In order to prevent pathogenic invasion and improve intestinal microbial balance, lactobacillus modulates microbial interventions. Restoration of microbial endostasis depends in large part on the synergism between lactobacillus bacteria and gastrointestinal commensal microflora **Zhang *et al*., (2018).**

2. Bifidobacterium

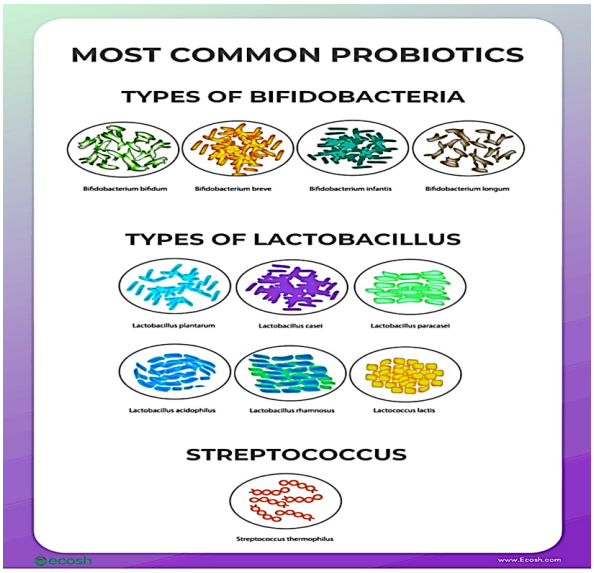
Physiological bacterium that found within human body considered one of the most important probiotic groups for humans. To maintain healthy gastrointestinal system, it has ability to produce probiotic-beneficial bifidogenic compounds and replicate and metabolized at the middle and lower part of gastrointestinal tract, **Valdemiro Carloss, (2011); Bested *et al*., (2013)**.

Bifidobacterium has the following physiological roles:

1) Prevent proliferation of harmful pathogenic bacteria to reduce proinflamatory cytokines and maintain the normal gastrointestinal homeostasis, **(Meng, *et al*., 2017; Makrasl & De Vuyst, 2006).**

2) By improving calcium bioavailability and facilitating the colon's synthesis of vitamins and amino acids, *Bifidobacterium bifidum* is thought to improve bone health **Dubey and Petel, (2018); Sadiq *et al*., (2021).**

3) Bifidobacterium conferred protection against cancerous tumors because Bifidobacterium acts as a distinctive anticancer protein carriers combating malignant tumor as well as released CPEPE23. One study on the mice's breast cancer the isolated Bifidobacteria, could stopped tumor's growth without producing any serious adverse effects on liver, kidney or weight loss of mice **Shimizu *et al*., (2020)**.



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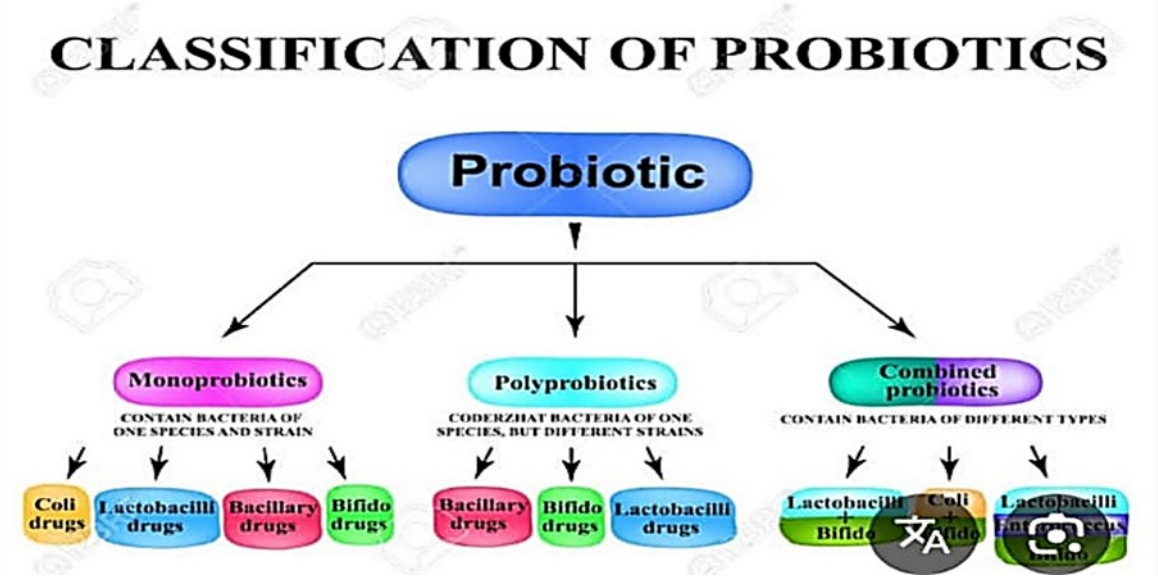
3. Saccharomyces: The yeast *S. cerevi*siae is one of nonpathogenic yeast and selective probiotics that is widely entered in the commercial probiotic meals production. As well as, *Saccharomyces cerevisiae* var *beulardii* is commonly used in controlling gastrointestinal tract disorder like diarrhea. Furthermore, it is more capable of surviving in the digestive tract than other probiotics, which helps to maintain the equilibrium of intestinal microbiota. Additionally, it alters immunological pathways in the event of pathogenic infections or chronic disorders by modulating immune system, **Paisp *et al*., (2020); Czerucka Rampal, (2019); Szajewska and Kolodziej, (2020).**

4. Enterococcus currently**,** are utilized in the fermentation process of food industry like in cheeses and sausages. Additionally, their ability to compete with, survive, and attachment to intestinal epithelium are a crucial features of a probiotic. Also, enterococcus are highly resistant to a wide range of temperature and pH due to their prominent capability to produce bacteriocin "a naturally occurring antibacterial agent" that can be entered in the industry of food, **Hanchi *et al*., (2018).** In addition to enterococcus, yeasts, *E. coli*, Bacillus species and Streptococcus species are more common prevalent probiotics.



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Mechanism of action

According to their effects on dietary proteins, probiotics change gut microbiota, improve the gut mucosal barrier, stop pathogen adherence and inactivation, change bacterial enzyme activity, affect mucosal permeability of the GI tract, and regulate immunity **(Betoret *et al*., 2003).** Probiotic contribute to the synthesis of metabolic by products like hydrogen peroxide, acid and bacteriocins such as acidophilin and lactocidin that have observable properties like antibiotics and suppress proliferation a range of microbes and potential pathogens, such as Salmonella, *Esherichia coli*, Klebsiella, Enterobacter, Serratia, Pseudomonas and Bacteroies, **Krasaekoop *et al*., (2003).** By producing short -chain fatty acids including butyric, acetic, propionic, formic and lactic acids, lactic acid bacteria lower pH of intestine and prevent growth of harmful germs. Significant levels of lactic acid produced by Bifidobacteria have antibacterial properties against bacteria, mold, and yeast, **Percivel, (1997).**

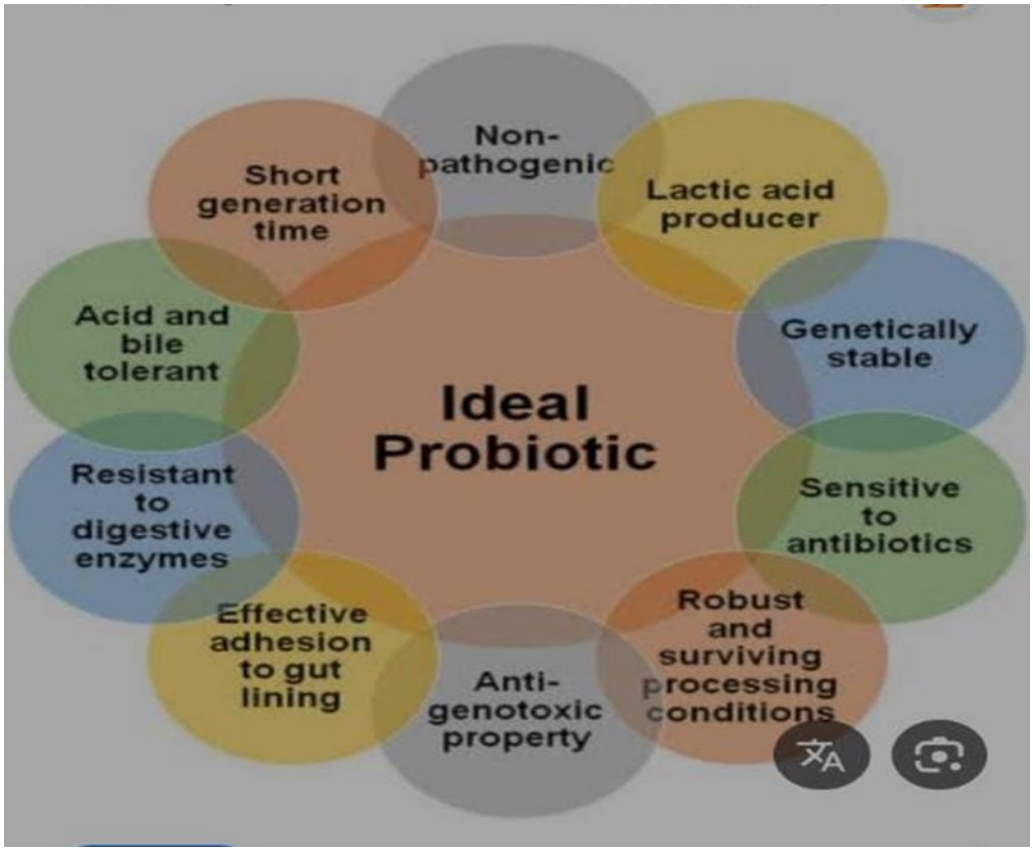
The role of probiotics and SARs-Covid-2 infection:

Although probiotics were previously thought to

improve the balance of gut microbiota, recent studies indicate that they may also benefit human immune responses, **(Klaenhammer *et al*., 2012)**. Probiotics have been presented to affect T cell subcategories and direct differentiation of Th17 cell in the small intestine, **Lee, (2017)**. Understanding the principles of immunological process behind the clinical symptoms associated infection of SARs-Covid-2 is essential for the evaluations and development of potential therapy. Numerous probiotics demonstrate antiviral properties, including against certain strains of virus corona, as shown in several laboratory studies **(Chai *et al*., 2013)**. One of the most interesting and documented beneficial effects of probiotics include their interaction with ACE2 receptor, the SARs-Cov2 host entry receptor. For instance, it has been showed that certain Lactobacilli synthesis peptides with a strong attraction for ACE receptors during fermentation process of milk **(Li *et al*., 2019)**. Currently, it was found that the carboxy peptidases that produced by Paenibacillus bacteria resemble ACE2 in the function and structure **(Minato *et al*., 2020).** Another study involving neonatal mouse model of influenza infection were given probiotic Lacticasei bacillus rhamnosus GG intranasally as a prophylactic strategy dependent on Toll-like Receptor (TLR4) signalling. cathelicidin LL-37of human, one of the most extensively studied antimicrobial peptides, that plays a critical role in preventing and reducing viruses and bacterial infections **(Mookherjee *et al*., 2020).** Also, the probiotic supplemented food including *Lactococcus lactis* can efficiently provide the human's body by this peptide. The beneficial effect of *Lactococcus lactis*, which contains cathelicidi, as a protective immunomodulatory using a probiotic delivery method that expresses antimicrobial peptides, **Wong *et al*., (2012)** may aid in creating new way for fighting SARs-Cov2 infection. The beneficial effects of local or oral consumption of these or other immunomodulatory for individuals infected with SARS-CoV-2 are still unknown. Aside from the probiotic benefits on upper respiratory system their ability to reduce common infections duration and incidence **(King *et al*., 2014)**, also reduction of need for pharmacological drugs and the duration of care facilities, **(Van Puyenbroeck *et al*., 2012)**. When the microbiota is disrupted by antibiotic therapy, probiotics might also be helpful. Probiotics have been recommended as a means to fortify the colonic microbiota and diminish secondary co-infections susceptibility due to experiential antibiotics, which are commonly applied at the earlier outbreak of (COVID-19) stages, can cause more severe and unfavourable dysbiosis. There is need for more clinical trials to prove the probiotic effectiveness, determining the best strains, dosing programs, and the duration time needed for treatment the infection with (SARS-CoV-2).

Probiotics and gut microbiota:

Consuming probiotics has a high correlation with good health. The microorganisms that are approved for consumption are often safe, selective strains that target particular population, including adult, newborns, and elderly. To achieve optimal health, one should also take into account the (recommended dietary allowance (RDA) of microorganisms, **Conigilo *et al*., (2023)**. Depending on the ideal medium (milk or soy milk), the amount of oxygen assimilated (stirred yogurt), the pH, the storage temperature, the presence of dietary components or probiotics, and other factors, different strains have varying rates of survival and growth in the stomach, **Ballan *et al*., (2020)**. By reducing unwanted dietary constituents (such raffinose and stachyose in soymilk), probiotics enhance health, **(Albuquerque *et al*., 2017; Battistini *et al*., 2018 and Champagne *et al*., 2018).** Although introducing starter strains such as *Streptococcus thermophiles* shortens probiotic cultures, this prevents Bifidobacterium strains from producing acetic acid tastes, **(Oliveira *et al*., 2009; Tripathi and Giri 2014; Champagne *et al.,* 2018).**



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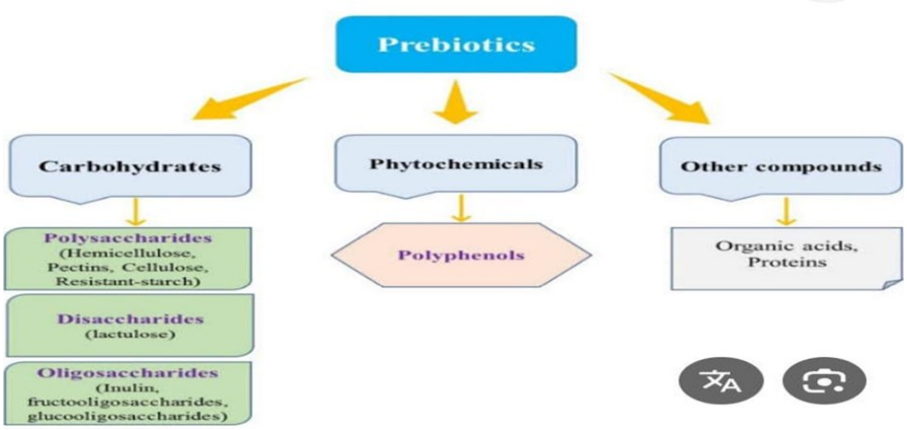
The concept of prebiotics:

Prebiotics is defined as especial an indigestible fibers part of the food that is not easily degraded by mammalian enzymatic degradation in the human body, withstand gastric acid and not absorbed by the gastrointestinal tract. This concept was first presented on 1995 according to **Gibson and Roberfroid, (1995).**

Prebiotics are non-digestible carbohydrates food ingredient that beneficially enhance the host's health by selectively growth stimulation and activation of some colon beneficial bacteria, generally (bifidobacteria and lactobacilli) according to **Gibson *et al*., (2004)**. Bifidogenic non- digestible oligosaccharides are easily fermented by beneficial gut microflora and selectively activate an indigenous probiotic bacteria of the lower gut, promoting its growth and activity to have a positive impact on the host. Under the assumption that they are good for the health, the probiotic and prebiotic international scientific association remodeled the prebiotics as selective fermenting ingredients that the intestinal microbiota utilized and transformed in a specific manner. In addition, non-carbohydrates are involved in the prebiotics' reviewed definition and their mode of action is not limited to the GI tract or the food, **Gibson *et al*., (2017).**

Prebiotics are oligosaccharides fermentable sugars that include fructose- oligosaccharides (FOS), glacto – oligosaccharides (GOS), xylo – oligosaccharides (XOS), inulin and lactulose as well as its derivatives, **Yin *et al*., (2022)**. Recently, many researchers found that prebiotics are more than only carbs that fix the criteria of the prebiotic including blueberries and black raspberries **(Jiao *et al*., 2019; and GU *et al*., 2019).** Some of important prebiotics that being generated from refining manufacturing processes include primarily polysaccharides, polypeptide polymers and polyphenols, which provide a great opportunities for developing new studies.

Types of prebiotics



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Glacto-oligo-saccharides (GOS)

A novel functional material with inherent qualities, that is difficult for the body to absorb and digest. Galactose and disaccharides (which include two galactose units) makeup the remaining two to eight sugar units that make up ,glacto – oligosaccharides ,including terminal glucose **Delgacto-Fernabdez *et al*., (2021).**

The distinct glycosidic bonds between galactose and glucose or between the polymerization degrees and molecules of galactose demonstrate the hybrid structure of (GOS) which is a key characteristic, **Torres, *et al*., (2010).**

glacto – oligosaccharides one of the most popular and extensively used prebiotics, has a number of beneficial function; they are very safe food additive according to numerous studies that have assessed their toxicity **Baeky *et al*., (2021),** also promoting Bifidobacterium intestinal population and preserving gut microbiota balance, **Ambrogi *et al*., (2021).** Newborn food formula and milk powder are the primary products that use GOS, as a result, they have received official safety approval in many legislations, **Slavin, (2013).**

1. Types of Inulin fructans

Inulin-type fructans (its hydrolysis product oligo-fructose) can satisfy prebiotic requirements, it is formed by joining a β-2,1 bond between terminal a- linked glucose and fructose to form inulin fructans. It is a part of GOS with longer chain of a degree of polymerization 2-60 **Wilson *and Whelan,* (2017).**

Several studies have investigated that inulin-type fructans has the ability to improve the survival and implantation of Bifidobacteria, Anthobacteria and Lactic acid producing bacteria (LAB) in the gut **Moens *et al*., (2017).** Inulin one of widely used prebiotics in food preparation as a versatile component such as flavoring of food, substitute fats or carbohydrates **Lightowler *et al*., (2018),** also, significantly enhance bioavailability and uptake of minerals like calcium, magnesium and iron, boosting immunity **(Wan *et al*., 2020).** In addition, reduce constipation and other gastrointestinal disorders **Bastard *et al*., (2020).**

2. Fructose- oligosaccharides (FOS)

Another well-known inulin-type fructan with short chain of degree of polymerization 2-8 called FOS. Banana, wheat, galic, Onion and other natural plants all contain non-digestible, low calorie carbohydrates that frequently used as prebiotic in the industry of food **(Agopian *et al*., 2008; Kumar *et al*., 2015; Pinto-Sanchez & Verdu, 2018; and Sunu *et al*., 2019).**

Several physiological beneficial effects of (FOS) include: reduction of carcinogenicity, improve absorption of mineral from gastrointestinal tract and lowered levels of serum cholesterol.

***Emerging prebiotics**

Algae, fruit and herbal remedies form a group of diverse sources of emerging prebiotics, as well as some microorganisms which produce polyphenols, polysaccharides and peptide poly-

mers. Although our recognition of prebiotics is not as advanced as that of GOS and FOS, their beneficial advantages need more investigation and hold hope for the future.

Prebiotics mode of action:

Prebiotics form a group of various carbohydrate components that generally able to resist intestinal digestion due to absences of hydrolyzing enzymes necessary for polymer bonds hydrolysis in the human gut, so they transported intact by the colon where they exposed to fermentation and degradation by intestinal microflora producing a secondary metabolic products that absorbed by the mucosa of intestinal epithelium and migrate via portal vein to the liver. These metabolites exhibit great health benefits like enhance function of intestinal barrier, stimulate absorption of minerals, modulating the immunity, pathogen resistance, and control levels of blood lipid (**Slavin *et al*., 2013; Cockburn *et al*., 2016; and Guarino *et al*., 2020).** One of the important benefit of prebiotics is promoting the formation of fermentation product's advantages and the enhancement of beneficial gut flora to compete with other pathogenic species after ingestion **(Ashaolu *et al*., 2020).**

Role of prebiotics and (SARs- Covid 2) infection:

It is commonly known that prebiotics treatments can improve gut-related disorders like diarrhoea and constipation as well as atherosclerotic cardiovascular disorder linked to dyslipidaemia, osteoporosis, obesity, insulin resistance and potentially diabetes of type-2 (**Wang *et al*., 2020).** Recently, Traditional Chinese Medicine (TCM) has been demonstrated treatment and recovery from COVID-19 according to the obtained data from the national administration of (TCM) **Ren *et al*., (2020)**. This protocol depend on cleansing of lung and Decoction detoxification which is prepared of polysaccharide-polymers that could have therapeutic benefits for (SARs cov-2) infections. These polymers are polysaccharides and oligosaaccride which belong to prebiotic group. Ninety percentages of the 214 covid- 19 patients who received this treatment, their symptoms resolved after three days, **Zhao *et al*., (2020)**.

Many researchers illustrated that cellular immunity is essential for eradicating viral infections. Prebiotic polysaccharides, the most important characteristics lie in the immune- modulatory capabilities **Li *et al*., (2020).** Chinese yam as example of prebiotics polysaccharides have been used as adjuvants in vaccine development and have immune-enhancing proprieties **Wu *et al*., (2020).** Most important of these polysaccharides called glycans **Lauc *et al*., (2016)**, which have repertoire of changes with ages that are most vulnerable to viral infection of (SARS COV2). Glycan variety considered one of the primary defences of the immune system against infections in all higher species thorough effector functions of regulator antibodies and several other aspects of immunity (**Lauc, 2020).** The glycosylation process of SARS and MERS glycoproteins revealed that each of the glycoprotein could be occupied by up to 10 glycans of different types referred to "glycoforms" (**Watanabe *et al*., 2020)**.

Role of prebiotics in gut microflora:

There are two possible health benefits of prebiotic include the alteration of gut microorganisms and the fermented metabolic products, like short chain fatty acids (SCFA) and tryptophan. The primary prebiotic pathway entails the purposeful fermentation of gut-dwelling improve microorganisms like Bifidobacterium and lactobacillus, which yield lactate and acetate respectively as well as encourage the production of butyrate. Furthermore it has been notice that SCFA production help mineral absorption, **Roager and Licht, (2018); Sanders *et al*., (2019) and Swanson *et al*., (2020).**

Probiotics of gut micrbiota fermented several prebiotics like, glucan, fructan and arabiroxylan. The final metabolites, SCFAs regulate host immunological response thorough a variety of routes via particular receptors**,Trompette *et al*., (2014).** Further more, the gut micro biota's fermentation of butyric and propionic acids from prebiotics can influence the activities of T lymphocytes, dendritic and macrophage cells. Short chain FAs also can affect systemic and intestinal antibodies of T dependent and T independent responses by functioning as histone deacetylation (HDAC) inhibitors. In addition, they have direct effect on B cell intrinsic activities by regulating specific miRNAs that target

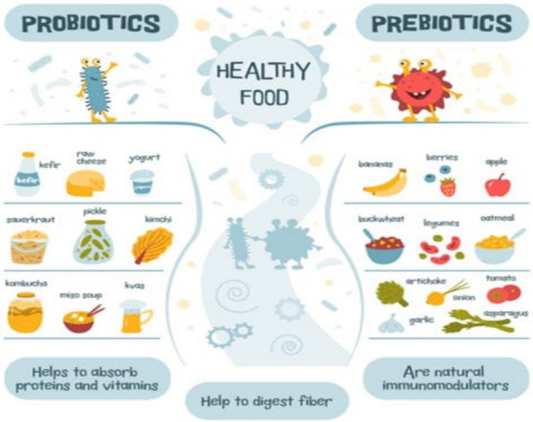
Prdm-1mRNA host genes and Aicda, **(Sanchez *et al*., 2020)**.
The most studied prebiotic component *Lactobacillus acidophilus* La-5, a probiotic discovered by **Santos *et al*., (2019)** was more resistant to GIT stress replicated in vitro than free cells when microencapsulated using inulin. They however, increase the survival rate **(David *et al*., 2014).**

Rosolen *et al*., (2019) revealed that the protective whey coating and inulin for *Lactococcus lactis* R7 improves heat resistance and in vitro GIT stress. Additionally, **Oliveira *et al*., (2009)** claim that the dairy products acidification rate is improved by co- culturing probiotics and specific strains with inulin. Prebiotic are consumed in a mixture with probiotics to create symbiotic, shorten fermentation times and increase probiotic survival rates throughout the gut **(Tripathi *et al*., 2014; & Markowiak *et al*., 2018).** Elsewhere, the fruit pulp addition to probiotic- fermented soymilk has a major impact on the final product **Peters *et al*., (2019).**

Prebiotics are frequently found in foods that include specific types of dietary fiber, whole grains, legumes, artichokes, asparagus, onions, garlic and bananas, (**Champagne *et al*., 2018; Kalita *et al*., 2023; & Mehmood *et al*., 2023).**

Conclusion

As live bacteria, probiotic beneficially affect the host health. As they can create antibacterial substances, improve the gastrointestinal barrier functions, and modulating the host immune responses to avoid infections additionally, aid in the management of intestinal disorders such as constipation and antibiotic- related diarrhoea.
Prebiotics are non-digestible fibres food ingredients that support the proliferation and function of positive gut micro-biome, also regulate the total bacterial variety of the gut via the effect on its lymphoid tissue. Numerous health advantages, including better nutrition absorption, decreased possibility of obesity, metabolic stress and deteriorating mental health are informed.
Therefore, both probiotics and prebiotics significantly affect quality of the life.



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