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Review Article

Pre/Pro-Biotics in Health & Diseases

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Abstract

Probiotics and prebiotics are a hot topic these days. The Western world sees many ads on television and online for supplements and foods that promise to deliver helpful bacteria and their benefits. The same culture is creeping in Urban India to an extent that educated urbanites are slowly moving to buying Greek Yogurt or commercial Probiotic products

Probiotics are microorganisms which confer a series of innate health benefits to the host, having a wide range of applications and are seen worldwide as miraculous advancement in nutrition and health besides their promising therapeutic benefits and negligible side effects. Indian probiotic industry is achieving its pace at steady rate with opportunities for rapid growth in near future. Indian probiotic market was valued at $12 million in 2011 and is estimated to be around USD 93.20 million in 2024 and expected to grow at a CAGR of 5.71% to reach USD 123.01 million by 2029.

There has been an increased influx of probiotic products in the Indian market during the last decade, in the form of Drinks, Supplements and Foods. The recent trends of incorporating probiotics into everyday food items like snacks, juices, and cereals, making it easier for consumers to incorporate probiotics into their daily diets. The rising popularity of veganism and lactose intolerance concerns, plant-based probiotics derived from sources like soy, almond, and coconut are gaining attraction and catering to the dietary preferences. The future of probiotic foods is promising, as modern consumers are making all out efforts for their personal health and expect their diet must be not only healthy but also capable of preventing illness. Currently they are available mainly in supermarkets of districts and larger cities, Pharmacies and a few online retailers. However, there has been no systematic approach for evaluation of probiotics in food to ensure their safety and efficacy.

Materials & Methods: This article is a review of changing physicians' prescription practices, with 4 case reports spread over 60 years. It also covers changes in dietary cultural practices, from Curd, butter milk in each meal, to more refined and costly commercial products called Probiotics. The author's observation as family physician since 1968 and as public health practitioner and consultant since 1978. The clinical practices of family physicians from advising curds and butter milk for diarrhea, to prescribing commercial probiotics for various health intervention trials. The article is complimented by literature review on production, distribution, marketing consumption trends and projected future for probiotics.

Kew Words: curds; buttermilk; pre-biotics; probiotics- diet; supplements &- probiotic particles loaded dressings; inflammatory bowel- diseases /syndrome (ibd/ibs); burns

Introduction

The research in the last decade is pointing to probiotic foods as beneficial against a range of health conditions, like allergies, arthritis, asthma, cancer, depression, hair growth, heart disease, and gastrointestinal (GI) problems and even helping in weight loss! Therefore, Probiotics & prebiotics are a hot topic of discussions & media advertisements these days [1].

Probiotics are microorganisms which confer a series of innate health benefits to the host, having a wide range of applications and are seen worldwide as miraculous advancement in nutrition and health besides their promising therapeutic benefits and negligible side effects. They are available in abundance in foods like yogurt and sauerkraut. Supplements [2].

Prebiotics are high-fiber foods that act as food for human microflora and are used with the intention of improving the balance of these microorganisms. They are available in whole grains, bananas, greens, onions, garlic, soybeans and artichokes. In addition, probiotics and prebiotics are added to some foods and available as dietary [2]. Traditionally most Indian households serve curd on its' own or curd rice, Butter milk /Chaas or Lassi at the end of every meal. It is even distributed by religious philanthropists free of charges in hot season to working class laborers to combat the heat waves. Commercial Yogurt is invading stores and supermarkets in the last 2 decades. Globally, come summer it is time to consume cold beverages, Yoghurt, and food items to beat the scorching heat. Curd is made by whisking some old Curd or lemon juice (yields several type Lactobacilli) with warm milk, kept overnight and consumed the next day [3].

This process of curdling & inducing probiotic bacteria to form Curd, gives this dairy product a unique taste and texture. On the other hand, Yogurt is prepared by fermenting the milk with artificial acids, commercially and needs an optimal temperature to get that perfect taste and smooth texture [4].

While both Curd and Yogurt contain probiotic bacteria, the quantity of bacteria in Yogurt is higher as compared to Curd, because of the way of fermentation over a period. Yogurt is made by commercial fermentation of milk by introducing a specific type of bacteria, resulting in a product with a type of bacteria, belonging to a similar family. Homemade curd on the other hand, has a comparatively lesser number of bacteria, not necessarily of the same or similar type of biological family. Modern consumer's efforts for their personal health are highly appreciable and their expectations that their diet must not only be healthy but also capable of preventing illness, has changed the clinical practices of family physicians from advising curds and butter milk for diarrhea, to prescribing commercial probiotics. This article is a review of changing physicians' prescription practices, with 4 case reports spread over 60 years. It also covers changes in dietary cultural practices, from Curd, butter milk in each meal, to more refined and costly commercial products called Probiotics. The article includes a literature review on production, distribution, marketing, consumption trends and projected future until 2029-30. Finally, It summarizes evidence based current therapeutic value and emerging guidelines for use of Probiotics and is expected to be a good guide to population and Physicians alike.

Anecdotal Case Reports from family Physicians in India:

1. **Buttermilk therapy for Young Infant with Traveler's Diarrhea 1969:** The authors' first ever experience of prescribing butter milk as a therapy goes back to May 1969. My cousin had come with her two kids to my rural PHC from Bhilai (Steel plant fame) Madhya Pradesh travelling by train in hot summer of temperature ranges between 38^0-42^0C for nearly 36 hours. After about 8 hours journey her son aged about 18 months developed diarrhea, and Railway Medical officer enroute had prescribed Bismuth subsalicylate (a stool binding suspension), and antibiotics (Rifaximin oral suspension) and an antiparasitic (Flagyl Oral suspension) along with oral rehydration. On arrival she was worried as the child continued to have diarrhea, was not feeding well. After reviewing his general condition and finding no dehydration I asked her i) to stop all drugs ii) Put the boy on a cup of butter milk (100ml) with a pinch of salt and a spoon of sugar every 3 hours. In just 24 hours, the miracle happened, Diarrhea diminished, appetite improved and in another 48 hours the child was normal.
2. **Trial of two Probiotics on patients with Diarrhea 2015:** In an urban health center, I tried on 2 well to do outpatients prescribing Lactobacillus Buchneri (SU) for 4 weeks & mixed probiotics (NS) for the following 4 weeks. Another 2 patients were given the same probiotics in reverse order (NS for 4 weeks at first and SU for the following 4 weeks). Fecal samples were collected before and after the outpatients took each of the two probiotics and analyzed in the district public health laboratory. While one child benefited (% of beneficial bacteria) after SU and another only after NS. Both patients in NS first order showed improved beneficial bacteria first and which decreased after SU. It was a lesson that Probiotics should be selected not only for their quality but also for compatibility with each intestinal bacterial flora.
3. **Shifting to Local Manufacturers Probiotics:** One of my IBD patients aged 45 years male, was referred to a Gastroenterologist in late 2023, who had prescribed an International Brand Probiotics (blend of Lactobacilli) for nearly 2 years with consistent satisfaction. As the cost was higher, I as his family physician suggested to try a total lactic acid bacterium and a total yeast counts probiotic manufactured locally. The cost is half of the brand he was already using. The result was consistent and satisfied gastroenterologist, me and our client. The patient continued to use the local brand, and the Gastroenterologist now comfortably prescribes the local brand probiotic for other patients for economic reasons.
4. **Probiotic Dressings of Burn wounds:** In November 2023 A boy was referred and admitted to a public sector tertiary hospital with post-crackers bursting burns (20%). The surgeon used Lactiplantibacillus plantarum strain of a probiotic strain loaded microparticles with proven wound-healing properties as dressings which turned out to be more effective. Histological investigations showed that the probiotic-loaded particles functioned exactly as efficaciously as silver sulfadiazine ointment. However, despite the effectiveness of probiotics in burn wound healing, their administration and stabilization are challenging because of the need for protection against Gram-positive and Gram-negative bacteria which requires the use of different forms of dosage as hydrogels, films ointments and gels.

Discussions:

Human large intestine contains 100 trillion "good" bacteria that are essential to health. They are called the gut microbiome, and they help maintain healthy bowel function, and may even help with conditions like inflammatory bowel disease. Research suggests they may even play a role in regulating weight and mood. In a healthy state, the gut microbiota has multiple positive functions, such as energy recovery from metabolism of nondigestible components of foods, protection of a host from pathogenic invasion, and modulation of the immune system. Imbalance of the normal gut microbiota also known as a dysbiotic state have been linked with gastrointestinal conditions like inflammatory bowel disease (IBD) and irritable bowel syndrome (IBS), and wider metabolic conditions like obesity, type 2 diabetes, and atopy. Specific contribution of the gut microbiota in these diseases is still unclear [1]. The heterogeneous etiology of metabolic and gastrointestinal diseases has been associated with different microbes, but the causal association is yet to be established.

Some of the best ways to add healthful bacteria to our microbiome i) Yogurt and kefir, one need to be sure to look for the words "live and active cultures" on the label to make sure of getting live cultures and ii) Fermented foods- Beneficial microbes are the "cooks" for some familiar foods as they turn cabbage into sauerkraut, cucumbers into sour pickles, soybeans into miso, and sweetened tea into kombucha. The best solution is to buy from producers who do the pickling themselves or carry fermented foods or make our own. It's best to stick with dietary sources rich in pre- and probiotics by including i) plenty of foods rich in insoluble fiber, which tend to contain the most prebiotics. We can find them in whole-grain products such as oatmeal and whole-grain breads, as well as in vegetables like asparagus, leeks, onions, and garlic, and starchy vegetables like sweet potatoes and corn. Beans, lentils, and peas are also good sources, ii) limiting sugar, saturated fat, and processed foods. These can deplete the good bacteria in the gut. The common difference between yogurt and curd are i) the way they are prepared, ii) amount of lactose iii) Nutritive value and iv) Flavors. [7]

Method of Preparation: The curd is made by coagulating milk with edible acids like lemon curd, juice and vinegar in a process known as curdling. Curd, known as Dahi in India, is made by fermenting milk with the help of Lactic Acid bacteria. This bacterium reacts with casein, a globular protein found in milk and then produces energy, Lactic acid is produced as a byproduct of such energy formation. This lactic acid then reacts with the globular proteins present in milk, denatures them, and results in the formation of a thick texture i.e., curd.

Sl. No.	Variables	Curd	Yogurt
1	**Preparation**	Fermentation of milk using Lactic Acid Bacteria	Fermentation of milk using live strains of Lactobacillus bulgaricus & Streptococcus thermophilus.
2	**Amount of Lactose**	Lower than fresh milk	Less lactose than curd
3	**Nutrition Value**	Calcium, Iron, Vitamin B 6 & Potassium,	Vitamin 12, Calcium, Phosphorus
4	**Flavors**	Unsweetened & Unflavored	Plain or sweetened, and variety of flavors.

Table-1 Comparison of Curds & Yogurt Characteristics.

Basic Steps of making curd at home:

i. Take a thick bottom pan, rinse it with clean water
ii. Add half a liter of clean and safe water, keep the pan on stove top and begin heating in low /medium flame
iii. Stern the milk 2/3 time while heating to avoid burning or browning from the bottom
iv. Frothing and bubbling of the milk indicates it's boiling
v. Turn off the stove and keep the milk aside to cool to room temperature till it is just warm (39-44^{0}C), checking with your finger (touch method) or a food thermometer.
vi. Add one (in summer) or two spoons (in winter) of curd starter to the milk.
vii. Then stir it well with a spoon or a wired whisk and leave it to settle.
viii. This mix can be poured into cups or vessels of Terracotta, steel etc.
ix. Cover with appropriate lids and leave it overnight or 6-8 hrs., the curd will be ready.

Basic Steps of making Commercial Yogurt:

Yogurt, on the other hand, is made by fermenting milk using live strains of two bacteria- Lactobacillus bulgaricus and Streptococcus thermophilus.

It is practically impossible to do it at home.

These bacteria react with the sugar present in milk and then produce lactic acid which then reacts with the protein in the milk and forms yogurt.

Yogurt is produced for commercial purposes and is artificially sweetened and made available in a variety of flavors.

The chemical reaction involved in the formation of Lactic acid is as follows:

$C_{12}H_{22}O_{11}$ (Lactose) + H_2O (Water) -> $4CH_3CHOHCOOH$ (Lactic Acid)

2. Amount of Lactose: Curd contains more lactose than yogurt but significantly less amount of lactose when compared to fresh milk. Therefore, lactose intolerant individuals can consume it, particularly Greek yogurt.

3. Nutritional Value: Curd is rich in calcium, iron, potassium, and vitamin B6, whereas yogurt is a wonderful source of calcium, phosphorus, and vitamin B12. Consuming yogurt lowers the risk of high blood pressure and cholesterol. On the other hand, curd is known to stimulate the brain and aids in the digestion process.

4. Flavours Available: Curd is traditionally consumed simply without any flavors. In Indian households, it is taken with either salt, sugar, jaggery, or neither or even as Lassi slated or sweetened. It is white in colour and has a sour or acidic flavor and is consumed as a crucial component of Indian cuisine. Yogurt comes in a wide variety of flavors, such as strawberry, mango, and blueberry. Yogurt has a less sour/acidic taste than curd. There are sweetened as well unsweetened yogurt available in the market.

Yogurt vs Curd! While Yogurt and curd are good for health and have nutritional values.

Yogurt is a great source of protein, potassium, molybdenum, pantothenic acid, or Vitamin B5. Because it is protein-rich, yogurt is beneficial for weight loss. It is advised for Hypertensive people due to its potassium content. Yogurt also contains probiotics, which help in maintaining healthy gut health. Curd is a great choice for people with indigestion issues as it helps in better digestion. The digestive system can easily absorb the nutrients in curd. The good bacteria present in curd help in maintaining a strong and healthy immune system. It is a strong source of calcium and phosphorus, which is good for overall bone health. Curd also has beauty benefits as it is beneficial for skin and hair.


Fig.1 Probiotic Products

General Uses of curd: Curd is a staple food in many cultures and is used for multiple purposes:

As a condiment: Curd is often used as a topping for dishes such as biryani.

In cooking: It is used to marinate meats and can also be used as a base for sauces and dips.

As a beauty product: Curd is often used by many people as a face mask and hair mask to improve the overall health and appearance of the skin or hair.

General Uses of yogurt

As a food item: Yogurt is a popular breakfast food that is either taken plain or with toppings such as fruits, nuts, granola, among others.

In cooking: Yogurt is sometimes used as a substitute for sour cream or cream in making sauces and dressings.

For health: Yogurt is rich in probiotics, which can improve gut health.

The Effects and Therapeutic Use of Probiotics

The effect of probiotics on human health has been studied in a wide range of conditions, focused on gastrointestinal conditions, atopic eczema, allergies, respiratory tract infections, obesity, metabolic disease/type 2 diabetes, cardiovascular, cognitive, and mental diseases, bone health, nonalcoholic fatty liver disease (NAFLD) and hepatic encephalopathy, tumor necrosis factor (TNF-α), autism, burn wounds, and gynecological diseases.

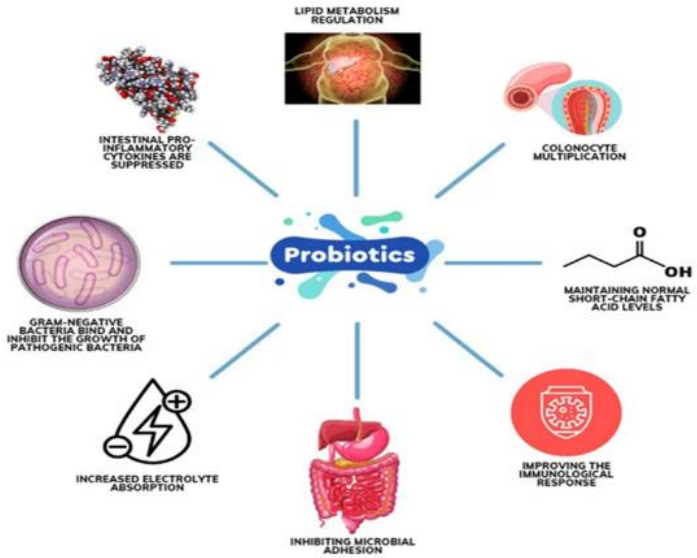

Figure 2. Action mechanisum of probiotics. Source. Ref

History and Benefits of Probiotic for Human Health:

The history of probiotics began in early civilization, when humans started to consume fermented foods. The first documented uses were around 2000 BC [1]. The first food producers turned milk into fermented dairy products using bacteria and yeasts. Our ancestors used yeast to make beverages as early as 3500 BC. It is believed that probiotics may treat or prevent different diseases both in children and adults. Ever since the early 2000s, probiotic-based fermented foods have had a resurgence in popularity, mostly due to claims made regarding their health benefits. Fermented foods have been associated with the prevention of irritable bowel syndrome, lactose intolerance, gastroenteritis, and obesity, chronic diarrhea, allergies, dermatitis, and bacterial and viral infections, all of which are closely related to an unhealthy lifestyle. An expanding range of candidate probiotic species is emerging that can lead to new variants of microbiome-modulating interventions like including prebiotics, symbiotics, postbiotics, microbial consortia, live biotherapeutic products, and genetically modified organisms, with renewed interest in polyphenols, fibers, and fermented foods to ensure human health [1].

Type	Strain	Function
Lactobacillus	*Lactobacillus acidophilus*	Used in the treatment of diarrhoea and for relief from the symptoms of irritable bowel syndrome; can reduce cytokines to relieve inflammatory bowel disease, modulate immunity, lower cholesterol, relieve diarrhoea, and alleviate cancer.
	Lacticaseibacillus casei	Prevention or treatment of diseases that disrupt the intestinal microbiota: diarrhoea and constipation, relief from the symptom of irritable bowel syndrome, and gingivitis, and the anti-inflammatory response.
	Lactobacillus rhamnosus	Has anti-diabetic and anti-viral activity; used to treat obesity; has the ability to fight against pathogenic bacteria and fungi in the genitourinary tract, preventing the recurrence of urinary tract infections in postmenopausal women; prevents enteric colonization by *Candida* species and treats recurrent *Clostridium difficile*-induced colitis in children; and has an effect on symptoms of maternal depression and anxiety during the postpartum period.
	Lactiplantibacillus plantarum	Has the ability to prevent the production of endotoxin; improves of the symptom of irritable bowel; and has antimicrobial activity and cholesterol lowering activity.
	Lactobacillus reuteri	Treatment of gingivitis in pregnant women and chronic periodontitis.
Bifidobacterium	*Bifidobacterium infantis*	Can improve the symptoms of irritable bowel syndrome and inhibits the secretion of allergen induced IgE.
	Bifidobacterium adolescentis	Can reduce inflammation of the spleen and brain and changes the microbiota of cecum and colon.
	Bifidobacterium bifidum	Can reduce cholesterol; is used in the treatment of infant diarrhea; and has greater cytokine (IL-6) production and active phagocytic properties.
	Bifidobacterium longum	Used in treating diarrhea and provides relief from the symptoms of irritable bowel syndrome; modulates the immune system through IL-10 production.
Other Lactic Acid Bacteria	*Streptococcus thermophilus*	Can produce antioxidant compounds and mitigate the risk of some types of cancer; has anti-inflammatory, antimutagenic effects and stimulates the gut immune system; and is useful in inflammatory bowel disease.
	Enterococcus faecium	Modulates the Th2-mediated pathologic response.

Table 2: Functions of Probiotics (source [1,2,5]

Lactose intolerance (LI): LI is a common problem globally and specifically in India in which people are allergic to dairy based products. In the context of Curd, it contains a lower amount of lactose as compared to fresh milk. The level of lactose intolerance may vary from person to person, and for such people curd is not highly recommended. Whereas the Greek-style Yogurt is highly recommended by experts for people suffering from lactose intolerance.

Benefits of probiotics for skin Health: These include protecting the delicate skin barrier to reduce the risk of inflammatory conditions like acne, eczema, and rosacea. By maintaining a balanced microbiome, probiotics help soothe irritation and regulate the skin response to external triggers such as UV rays and pollution. They also stimulate skin cell turnover, promoting a smoother and brighter skin tone over time. In addition to their anti-ageing properties, probiotics can diminish wrinkles and fade blemishes, offering you youthful skin. Probiotics can also hydrate and nourish your skin, combating skin dryness. Oral & topical use of probiotics can help 6 health conditions or diseases, according to Indian dermatologist:

1. Help deal with acne: Acne is caused by clogged pores, inflammation, and bacterial growth, often exacerbated by an imbalance in the skin's microbiome. According to a research paper published in 2020 by Clinical and Experimental Dermatology, probiotics, especially strains like Lactobacillus and Bifidobacterium, exhibit antimicrobial properties that can help inhibit the growth of acne-causing bacteria such as Cut bacterium acnes. By reducing bacterial load and inflammation, probiotics may help in preventing and managing acne breakouts. Avoid the urge to pop your pimples since it can lead to permanent acne scars [11].

1. Reduce signs of ageing: As we age, the skin undergoes several changes that may result in reduced collagen production, diminished elasticity, and increased visibility of wrinkles and fine lines. Probiotics offer anti-ageing benefits by stimulating collagen synthesis and improving skin barrier function. A 2016 study published in the Journal of Drugs in Dermatology inferred that using probiotics for the skin can restore skin pH balance, reduce damage caused by UV light, and lower oxidative stress

2. Help to deal with Atopic dermatitis: Atopic dermatitis (AD), also known as eczema, is a chronic disease that causes inflammation, itching, redness, and irritation of the skin. Topical use of probiotics can reduce the number of S. aureus and AD symptoms. Applying probiotic-containing skin care products reduces acne outbreaks and help manage dry skin & eczema.
3. Control psoriasis: Psoriasis is an autoimmune condition, in which the immune system becomes overreactive and causes rapid turnover of skin cells, leading to thick, scaly patches on the surface of the skin. These inflamed patches can be mostly seen on the scalp, elbows, and knees; however, other body parts can also be affected. A study published by the British Journal of Dermatology, inferred that oral probiotics are effective in managing psoriasis.
4. Rosacea: Chronic inflammation, stress, shifts in skin pH, and dietary choices, among other factors, can disrupt microbial balance. This imbalance may lead to infections or skin conditions such as acne, eczema, and rosacea. Rosacea, specifically, is a chronic inflammatory skin disorder primarily affecting the face and causing redness, visible blood vessels, and sometimes pimples or bumps. Unlike acne-related redness around acne spots, rosacea typically causes flushing that occurs more commonly at the center of the face. A recent review published in Frontiers in Microbiology suggests that using probiotics could significantly alleviate rosacea symptoms.
5. Wound healing: Probiotics may also be effective in promoting wound healing by accelerating the repair process and reducing the risk of infection. Older research published by Clinical Microbiology and Infection found that using Lactobacillus

plantarum probiotics can accelerate the healing of wounds and burns as was referred in our case of burns. However, more research is needed to support this benefit.

Figure 3: Acne

Best probiotics for the skin: When looking for skincare products containing probiotics, dermatologist advise to look for something with one or more of the following ingredients:

Lactobacillus: Effective in reducing redness and acne.

Bifidobacterium: Ideal for people with dry, irritated skin or eczema.

Vitreoscilla: Helps maintain skin moisture levels.

Streptococcus thermophilus: Boost ceramide levels, particularly for sensitive skin or eczema.

Bacillus coagulans: Can help combat skin ageing.

Staphylococcus epidermidis: Inhibit the growth of infection-causing bacteria on the skin.

Ways to use probiotics to improve skin health:

1.Diet: Incorporate probiotic-rich foods such as yoghurt, kefir, sauerkraut, and kombucha into your diet to promote a healthy gut microbiome, which indirectly supports skin health.

2. Supplements: Take oral probiotic supplements containing strains beneficial for skin conditions like acne or eczema. These supplements can help balance the gut microbiome, potentially improving skin appearance and reducing skin problems.

3. Topical use: Use skincare products containing probiotics directly on the skin, such as creams, serums, masks, foundations, gels, cleansers, primers, etc. These topical treatments can help maintain the skin microbiome, support barrier function, and alleviate conditions such as acne or inflammation. Side effects of probiotics on the skin? While probiotics generally benefit skin health, some people may experience mild side effects such as temporary redness, itching, or irritation. These reactions are usually a result of an allergy to probiotics. Better to perform a patch test before full application and to start with lower concentrations to understand its effect on your skin [1, 11].

Efficacy of probiotics in hair growth and dandruff control:

A Meta-analysis of eight randomized clinical trials and preclinical studies recently reported a non-significant improvement in hair count (SMD = 0.32) and a significant effect on thickness (SMD = 0.92). In preclinical studies, probiotics significantly induced hair follicle count (SMD = 3.24) and skin thickness (SMD = 2.32,). VEGF levels increased significantly (SMD = 2.97), while IGF-1 showed a non-significant inducement (SMD = 0.53). For dandruff control, two studies demonstrated non-significant improvement in adherent dandruff (OR = 1.31) and a significant increase in free dandruff (OR = 5.39). Hair follicle count, VEGF, IGF-1, and adherent dandruff parameters were recorded with high heterogeneity. For the systematic review, probiotics have shown potential in improving hair growth and controlling dandruff through modulation of the immune pathway and gut-hair axis. The Wnt/β-catenin pathway, IGF-1 pathway, and VEGF are key molecular pathways in regulating hair follicle growth and maintenance [12].

Probiotics- Global & Indian Market and Future:

The global probiotics market was valued at USD 71.8 billion in 2023 [11,12]. The market has witnessed significant growth due to rising health consciousness, increasing disposable income, and the growing popularity of functional foods. Indian probiotic market was valued at $12 million in 2011 and is estimated to be around USD 93.20 million in 2024 and grow at a CAGR of 5.71% to reach USD 123.01 million by 2029 [13]. Major players in the Indian probiotics market include Yakult Danone India Pvt. Ltd., Nestle India Ltd., Amul, and Dr. Reddy's Laboratories.

The Indian government's emphasis on improving public health through various initiatives is fostering the growth of the probiotics market. For instance, the "National Nutrition Mission" aims to reduce malnutrition and promote healthy eating habits among the population.

The rise in the consumption and market share is attributed to i) Increasing Health Consciousness- In 2024, over 500 million people in India are actively seeking health-enhancing products, including probiotics, driven by growing awareness of the benefits of probiotics in improving digestion, boosting immunity, and preventing gastrointestinal issues. ii) Rise in Digestive Disorders: The prevalence of digestive disorders in India has increased substantially in recent years. Conditions like irritable bowel syndrome (IBS) and inflammatory bowel disease (IBD), diarrhea are becoming more common due to changing dietary habits and lifestyle factors. Probiotics are being increasingly prescribed by doctors, especially Gastroenterologists as a therapeutic & preventive measure for these conditions. iii) Government Support for Probiotics: In 2024, the Department of Biotechnology (DBT) under the Ministry of Science & Technology released guidelines for the evaluation of probiotics in food to help conduct research and promote its use in the industry. In February 2024 the DBT also organized a workshop on "Biomanufacturing of Probiotics and Fermented Foods: A Step Towards Health Status and Social Well-Being" [5].

The growing probiotics market in India is contributing significantly to the country's overall health and wellness industry. It creates opportunities for local manufacturers, generating employment, promoting research and development activities in microbial & gut health [13].

North India is currently the dominant region in the Indian probiotic market, accounting for the largest market share. This dominance is attributed to the presence of major dairy companies and advanced distribution networks in

North India. South India still has predominant practice of consuming curds in various recipes with each meal. Higher health awareness, better access to healthcare facilities, and higher disposable incomes in the region add to market value.

The future of probiotic foods is promising, as modern consumers are making all out efforts for their personal health and expect their diet must be not only healthy but also capable of preventing illness.

While there has been an increased influx of probiotic products in the Indian market during the last decade, there has been no systematic approach for evaluation of probiotics in food to ensure their safety and efficacy [3].

It's best to stick with dietary sources rich in pre- and probiotics. We can help our body produce healthy gut bacteria by a) Including plenty of foods rich in insoluble fiber, which tend to contain the most prebiotics. We will find them in whole-grain products such as oatmeal, whole-grain breads, vegetables like asparagus, leeks, onions, and garlic, and starchy vegetables like sweet potatoes and corn. Beans, lentils, & peas are also good sources. ii) Limiting sugar, saturated fat, and processed foods, because they deplete the good bacteria in the gut.

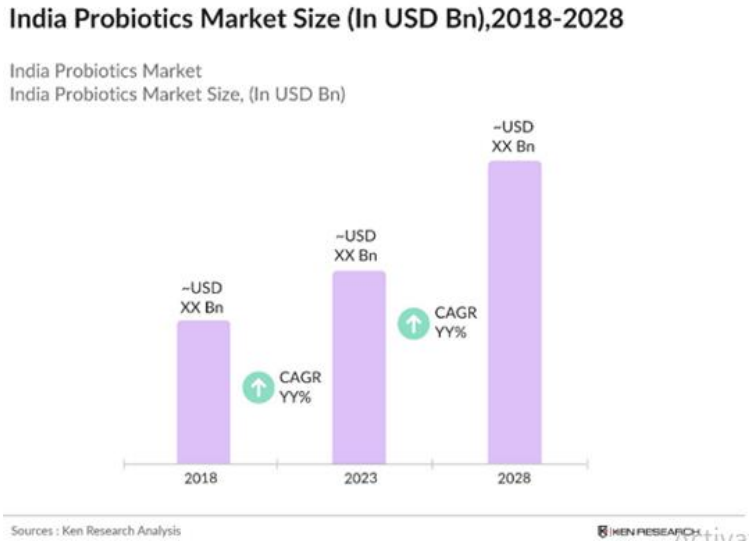

Figure 4: Source-ken research [12]

Summary:

Probiotics are microorganisms which confer a series of innate health benefits to the host, having a wide range of applications and are seen worldwide as miraculous advancement in nutrition and health besides their promising therapeutic benefits and negligible side effects. The rise in the consumption and market share is attributed to i) Increasing Health Consciousness of the benefits of probiotics in improving digestion, boosting immunity, and preventing gastrointestinal issues. ii) Probiotics are being increasingly prescribed by Specialist doctors, especially as a therapeutic & preventive measure for various conditions.

Indian probiotic market was valued at $12 million in 2011 and is estimated to be around USD 93.20 million in 2024 and grow at a CAGR of 5.71% to reach USD 123.01 million by 2029.

The emerging guidelines for use of Probiotics include:

➢ Probiotics must be administered on an empty stomach.

➢Heat-dried formulations be kept at 4 °C, & lyophilized forms can be kept at room temp.

➢A probiotic is administered 1 or 2 times a day & the dosage 1 to 10 billion (108–109) CFUs.

➢ For patients who take antibiotics, the dosing time must be separated with an interval of two hours between them

The future of probiotic foods is promising, as modern young consumers are making all-out efforts for personal health & expect their diet to be healthy & prevent illness.

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