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Probiotics: Health benefits-An update

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Abstract

Probiotics have always been a vital component and commercial target for providing potential health benefits. The health benefits of probiotics are associated with preventing and reducing many diseases, i.e., allergic diseases, cancer, vaginal infections, hypercholesterolemia, lactose intolerance, inflammatory bowel disease, diarrhea, and irritable bowel syndrome. The gut microbiome is a viable therapeutic target for managing allergic diseases, as they modulate the immunological and inflammatory response that consequently affects the development of sensitization and allergy. The advantages of probiotics are related to the modulation of gut microbiota, mitigation of nutritional intolerances (lactose intolerance), increase in bioavailability of macro and micronutrients, and alleviation of allergic incidences in susceptible individuals. Probiotics can be used as an effective tool for lowering blood cholesterol levels. They can act directly or indirectly to decrease cholesterol levels in the body. The gut plays a pivotal role in the digestion and absorption of nutrients and maintains mucosal barrier integrity. The application of probiotics is a safe, effective, and natural way to support women's health. There is many microbial colonization in the vagina of healthy women, among which *Lactobacillus* plays a major role (95%). Overall, *Lactobacilli* and *Bifidobacteria* are indicators of a healthy vaginal microbiome. Probiotics have been widely used in the treatment of intestinal diseases, but the effect of probiotics on female reproductive tract health (vaginal infections) is still controversial.

Keywords: Gut Microbiota; *Saccharomyces Cerevisiae*; Probiotics; Lactic Acid Bacteria; Immunomodulation; Anti-Allergic and Gastrointestinal Diseases; Functional Foods; Vaginal Infections

1. Introduction

Yeast probiotic (*Saccharomyces cerevisiae*), has been shown to improve intestinal microbial composition and stimulate immune function [1, 2-72, 80]. A large number of food items, including yogurt, buttermilk, idly, dosa, Indian pickles, or achaar, and powdered milk. Sol Kadhi is a Indian traditional probiotic drink from the Konkan region of Maharashtra and Goa. Kanji is a traditional North Indian probiotic drink made from fermented black carrots or beets, frozen fermented dairy desserts. Kefir is known for its probiotic properties and is often consumed as a health drink, cheese and cheese

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products, ice creams, baby foods, and cereals[1, 2-72, 80]. Gundruk is a traditional fermented leafy green vegetable dish from the Indian Himalayan region, with fermented rice[1, 2-72, 80]. Dhokla is a popular Gujarati snack made from fermented chickpea flour. Kanji and Kombucha are two probiotic beverages that have gained popularity in India for their health benefits and unique flavors, and fruit juices, are among numerous probiotic foods [1, 2-72, 80]. The term "probiotic" was first presented by Werner Kollath in 1953, which is known to be a derivative of the Latin word pro and the Greek word β ιο meaning "for life." [2]. Kollath defined probiotics as active bodies with essential functions for promoting various health aspects [2]. On the other hand, Food and Agriculture Organization (FAO) and World Health Organization (WHO) described them as "live microbes when administered in adequate quantities, confer health benefits on host organisms [2]. Probiotics, like lactic acid bacteria, are non-pathogenic microbes that exert health benefits to the host when administered in adequate quantity [2-45]. Due to their capability to modulate gut microbiota and attenuate the immune system, probiotics could be used as an adjuvant in hypertension, hypercholesterolemia, cancer, and gastrointestinal diseases [1, 2-50, 80].

On the basis of literature survey [1, 2-71], it is found that the most prominent barrier to using probiotics in the food industry is their sensitivity toward heat treatments during processing and GI stresses in the human body [1, 2-71]. Probiotics are commonly used in dairy, beverage, baking, and edible film industries [1, 2-45]. Lactic acid bacteria (LAB) in dairy products helps to increase the shelf life of fermented products. LAB act as antimicrobial agents against many pathogens living inside the human body, thus improving human health [1, 2-71]. Considering the functional properties, probiotics are being used in the dairy, beverage, and baking industries [1, 2-50, 80]. After developing the latest techniques by researchers, probiotics can now survive within harsh processing conditions and withstand GI stresses quite effectively [1, 2-72]. Thus, the potential of probiotics can efficiently be utilized on a commercial scale in food processing industries [1, 2-45]. Probiotics prevent pathogenic bacteria by restricting binding sites on mucosal epithelial cells and modulating the host immune response, thus improving intestinal barrier integrity [2-71]. The advantages of probiotics are related to the modulation of gut microbiota, mitigation of nutritional intolerances (lactose intolerance), increase in bioavailability of macro and micronutrients, and alleviation of allergic incidences in susceptible individuals [2-50]. The approximate consumption of 109 colony-forming unit (CFU)/day have been revealed as an effective dose [2]. By keeping in view, the effective dosage, probiotics are being incorporated into many foods like beverages, ice cream, yogurt, bread, and many others by the food industry [2].

2. Probiotics: Health benefits

Probiotics, in the form of supplements or food products, have emerged as the most prominent ingredient in the era of functional foods [2-60]. Probiotics have always been a vital component and commercial target for providing potential health benefits [2]. The frequently used strains belong to the divergent group of *Bifidobacterium* and *Lactobacillus* that significantly affect health with various actions. They detoxify xenobiotics and environmental pollutants, bio-transform mycotoxins in foods synthesize vitamin K, riboflavin, and folate, and ferment undigested fiber in the colon [2-71]. Probiotics can be consumed either by incorporating them into foods or drinks in the form of dairy or non-dairy foodstuffs or as supplements [2-65]. Various fermented foods have active microbes genetically similar to the strains utilized as probiotics [1-2-65]. It has been observed that fermented foods enhance the functional and nutritional aspects by transforming substrates and producing bioactive and bioavailable end-products [2-72]. The health benefits of probiotics are associated with preventing and reducing many diseases, i.e., allergic diseases, cancer, vaginal infections, hypercholesterolemia, lactose intolerance, inflammatory bowel disease, diarrhea, and irritable bowel syndrome [2-50]. The gut microbiome is a viable therapeutic target for managing allergic diseases, as they modulate the immunological and inflammatory response that consequently affects the development of sensitization and allergy [2-70].

In one of the studies reported by Xu et al., (2025) [1] *Saccharomyces cerevisiae* supplementation during rapid dietary transition in dogs led to beneficial changes in blood parameters, increased fecal IgA levels, and promoted a more stable gut microbiota [1]. These findings suggest that yeast probiotics may support gut health and immune function during periods of dietary change [1]. The study reported by Xu et al., (2025) [1] also confirmed that rapid dietary transition in dogs can disturb the balance of gut microbiota, resulting in symptoms such as diarrhea and compromised immune function [1]. However, the composition of gut microbiota undergoes dynamic changes in response to various factors including age, diet, medication, and environmental conditions [1]. Probiotic supplementation has emerged a potential strategy to promote gut health during dietary transitions by modulating microbial composition and enhancing intestinal homeostasis [1]. The study reported by Xu et al., (2025) [1] also indicated that dietary transitions significantly alter the composition of gut microbiota and their metabolites in dogs [1]. Additionally, supplementation of yeast probiotic *Saccharomyces cerevisiae* attenuates these changes [1]. Yeast probiotic *Saccharomyces cerevisiae* can increase fecal IgA levels in dogs and modulate changes in gut microbiota and metabolites after dietary transitions [1]. However, further research is needed to confirm these potential effects on a larger population using different diet's composition [1]. Currently, research is being conducted on the molecular events and applications of probiotics [2]. The suggested

mechanisms by which probiotics exert their action include; competitive exclusion of pathogens for adhesion sites, improvement of the intestinal mucosal barrier, gut immunomodulation, and neurotransmitter synthesis [2].

Probiotics have well-documented physiological effects with a definitive mechanism [2-39]. However, the exact mechanism of how they work to enhance health and prevent different diseases must be explored [2-30]. Evidence from well-documented clinical trials has revealed that probiotics can potentially alleviate different GI and other disorders [2-41]. Moreover, many studies have been done on the animal model, so there is an emergent need to translate these results into humans [2-45]. However, genetically modified bacteria can be used for exploring innovative strategies to deliver bioactive molecules to mucosal tissues [2-25]. More consistent and reproducible clinical trials are required to reveal probiotics efficacy, limitations, and safety, determining their effects on the immune system [2]. Therefore, probiotics can be applied easily by food producers to make novel functional foods to promote human health [2-65].

Many products, such as pasteurized milk, infant formula, fermented milk, and ice creams are being produced and consumed worldwide as probiotic-based dairy products [2-71]. Some products like cheese and fermented milk are preferred as probiotics carriers because their pH buffering capacity and fat contents give additional protection to probiotics while passing through the GI tract [2-71]. Yogurt, including reduced lactose or lactose-free, functional ingredient-supplemented yogurts such as vitamins, minerals, sterols, stanols, conjugated linoleic acids, prebiotics, and probiotics have also gained good market success for quite a long period [2-50]. Consuming probiotic food is more readily acceptable to consumers as it is a more natural way of receiving their daily dose of probiotics [2-71]. Fruit juices supplemented with probiotics have been reported as a more unique and appropriate method in the probiotic beverage industry [2-72, 80]. Fruit juices have been accepted widely among all consumers regardless of age, gender, and geographic region around the globe due to the presence of essential nutrients [2-35]. The viability of probiotics is shorter in non-dairy foods when compared to dietary supplements due to the harsh environments faced by probiotics in beverages [2-72]. Processors must consider many factors in the production of probiotic juices, such as pH, temperature, anthocyanins, and most importantly a vegetative form of probiotics [2-61]. The beverage prepared from whey, germinated millet flour, and barley extract was treated with L. acidophilus in another study, and it was found to be effective in controlling the pathogenicity induced by Shigella in mice models [2-71]. The beverage stimulated the immune response and enhanced the IgA level, thus controlling pathogenicity [2-71]. One of the study used *L. plantarum* to make a beverage from coconut water after fermentation [2-71]. This process not only enhanced the vitamin and mineral (potassium, calcium, and sodium) contents but also improved anti-hypertensive, antioxidant, and antimicrobial properties making it suitable for use [2-72, 80]. Bakery products (bread, biscuits, doughnuts, cookies, etc.) contribute to several major food components such as carbohydrates, proteins, fats, dietary fiber, vitamins, and minerals in varying amounts [2-72, 80].

Probiotics regulate the innate and adaptive immune response modulating dendritic cells (DC), macrophages B and T lymphocytes [2-35]. Probiotics, live microorganisms that confer health benefits to the host when administered in adequate amounts, have gained considerable attention for their potential role in maintaining women's health [2-72]. Probiotics, particularly *Lactobacillus* species, contribute to vaginal health by promoting a balanced vaginal microbiome to prevent infections and maintain an acidic environment [1-9]. In gynecologic conditions, probiotics showed potential in preventing and managing bacterial vaginosis, vulvovaginal candidiasis, and sexually transmitted infections [1-9]. Probiotic supplementation has also been associated with improvements in metabolic parameters and menstrual irregularities in polycystic ovary syndrome patients [1-9]. During pregnancy, probiotics may be helpful in reducing the risk of gestational diabetes, maternal group B streptococcal colonization, obstetric anemia, and postpartum mastitis [1-9]. In recent years, the potential role of probiotics in the prevention and management of gynecologic cancer has gained attention [1-9, 73-77-79].

Probiotics also increased the production of anti-inflammatory cytokines while interacting with intestinal epithelial cells and attracting macrophages and mononuclear cells [2-55]. Furthermore, probiotics can produce neurotransmitters in the gut through the gut-brain axis [1-57] Specific probiotic stains can modulate the serotonin, gamma-aminobutyric acid (GABA), and dopamine levels, affecting mood, behavior, gut motility, and stress-related pathways [2-25]. Probiotics possibly exert a positive potential on the human body through these main mechanisms; competitive exclusion of pathogens, improvement in intestinal barrier functions, immunomodulation in the host's body, and production of neurotransmitters [2-55]. Probiotics compete with pathogens for nutrients and receptor-binding sites, making their survival difficult in the gut [2-50]. Probiotics also act as anti-microbial agents by producing substances; short chain fatty acids (SCFA), organic acids, hydrogen peroxide, and bacteriocins, thus decreasing pathogenic bacteria in the gut [2-45]. Moreover, probiotics improve the intestinal barrier function by stimulating the production of mucin proteins, regulating the expression of tight junction proteins, including occluding and claudin 1, and regulating the immune response in the gut [2-44]. Probiotics could be used as an adjuvant for various types of cancers based on their potential to modulate enteric flora and enhance local and systematic immunity [1-44, 73-80]. They prevent the initiation, progression, and

metastasis of transplantable or chemically induced tumors [2-61, 73-80]. Probiotics can be used as an effective tool for lowering blood cholesterol levels. They can act directly or indirectly to decrease cholesterol levels in the body [2-50]. The gut plays a pivotal role in the digestion and absorption of nutrients and maintains mucosal barrier integrity [1-45]. Numerous commensal bacteria reside in the human GI tract constituting an active community, which strongly affects human physiology [2-44]. The modification in intestinal microflora can be achieved by administering antibiotics, probiotics, prebiotics, and fecal transplant [2-35]. The encapsulation of probiotics into edible films protects them from premature degradation and increases their viability in the human body [1-26]. The technique of edible films is being used nowadays as a tool for the effective delivery of probiotics to consumers [1-44].

The association between probiotics and human health has been well-known for an extended period. When consumed orally, probiotics can regulate the composition of intestinal microbiota [1-70]. However, the severe physicochemical stresses (high temperatures and acidity during processing, storage, and passage to the large intestine) can drastically reduce the viability of probiotics [1-59]. Researchers have used different encapsulating techniques to overcome these stresses and enhance the viability of probiotics within the human body [1-20]. The traditional and most widely used technique is microencapsulation [1-9].

3. Probiotics: Women Health

Probiotics are more than a mix of gut-friendly bacteria. They are a blend of live microorganisms with benefits to the body—beyond the health of the digestive tract [1-9-71]. For example, the skin, mouth, penis and vagina have unique microbiomes of their own [3-9]. While commercial probiotics catering to all of these microbiomes do not yet exist, vaginal probiotics do [3-9]. They dominate the shelves of drugstores and supermarkets with the notion that "vaginal" probiotics can boost vaginal health, similar to how "gut" probiotics can improve gut health [3-9]. Vaginal probiotics promise to seed the vagina with "good" microbes that keep the pH and odor in check and support the health of the vaginal and urinary tract [3-9]. However, most of the claims lack scientific evidence to support them [3-9]. Some small-scale clinical trials have tested the use of vaginal microbes (probiotics) to treat bacterial, yeast and sexually transmitted infections, but none have demonstrated effectiveness that supports FDA clearance and large-scale marketability [3-9]. The vaginal microbiome is not static [3-9]. Microbial communities shift with different seasons of life, including birth, pre-puberty, puberty and menopause [3-9]. Genetics, geography, ethnicity and lifestyle factors also impact vaginal microbiome populations [3-9]. Defining a disease-free vaginal state is, therefore, complicated; but, in general, the vaginal microbiota can be classified into 5 community state types (CSTs) [3-9]. These CSTs can be thought of as the 5 most likely combinations to make up the vaginal microbiota in women of reproductive age [3-9]. *Lactobacilli* species occupy about 70% of the healthy vaginal microbiome during reproductive years, but *Lactobacilli* found in the vagina are not the same as the ones that reside in the gut [3-9]. In fact, although 250 types of *Lactobacilli* are known in nature, 4 out of 5 CSTs are dominated by *Lactobacilli* species: *L. crispatus, L. gasseri, L. iners* and *L. jensenii*, which are generally known for their protective qualities [3-9]. For instance, these organisms convert sugars in the vaginal walls to lactic acid, generating a slightly acidic environment that is hostile to incoming pathogens [3-9]. Additionally, they produce antimicrobial peptides, such as bacteriocin, to kill competing microbes, and can even physically take up space to keep pathogens from establishing themselves [3-9]. The vaginal microbiota (VMB) plays a crucial role in women's health from puberty to menopause [3-9]. Traditional studies have focused on the microorganisms present within the vaginal environment and their roles in disease onset. However, the dynamic relationship between the VMB and its host remains underexplored [3-9].

Probiotics, especially certain *Lactobacillus* species, can benefit vaginal health by maintaining a balanced vaginal microbiome, preventing infections, and supporting an acidic environment [3-9]. These beneficial bacteria can help to reduce the occurrence of bacterial vaginosis (BV) and other vaginal infections [3-9]. Consuming probiotics has become a popular way to improve digestive health [3-9-70]. Probiotics are healthy bacteria strains found naturally in some foods and in nutritional supplements [1-3-71]. More recently, health experts have begun to consider the potential benefits of probiotics on vaginal health [3-9]. *Lactobacillus acidophilus* is the most-researched strain of probiotic when it comes to establishing and maintaining a healthy vaginal balance [3-9]. Two other important strains include *lactobacillus rhamnosus* and *Lactobacillus reuteri*. [3-9]. Experts believe these strains helps to maintain vaginal balance by sticking to vaginal surfaces and making it more challenging for harmful bacteria to grow. *Lactobacillus* may also adhere directly to harmful bacteria, killing them and preventing them from spreading [3-9]. There is many microbial colonization in the vagina of healthy women, among which *Lactobacillus* plays a major role (95%) [3-9].

Vaginal dysbiosis and related infections are common, often causing discomfort and leading to medical consultations [3-9]. Conventional treatments with antibiotics and antifungal drugs are not always effective and can disrupt beneficial lactobacilli, potentially leading to recurrent BV and VC [3-9]. Therefore, more effective and natural solutions are needed to balance the VMB and maintain a healthy vaginal environment [3-9]. Probiotics, particularly lactobacilli, have emerged

as promising candidates for maintaining or restoring a healthy VMB post-antibiotic treatment [3-9]. Systematic reviews and meta-analyses suggested that probiotics may help mitigate BV and VC, enhancing the quality of life for affected women [3-9]. Probiotics support the balance of the vaginal microbiota, promoting the growth of beneficial bacteria, preventing harmful microorganisms' overgrowth, and strengthening the immune system [3-9].

Probiotics have been widely used in the treatment of intestinal diseases, but the effect of probiotics on female reproductive tract health is still controversial [3-9]. *Lactobacillus* is the most abundant microorganism in the vagina, which is related to the vaginal mucosal barrier [3-9]. *Lactobacillus* adheres to the vaginal epithelium and can competitively antagonize the colonization of pathogens [3-9]. The factors produced by *Lactobacillus*, such as bacteriocin and hydrogen peroxide (H_2O_2), can inhibit the growth of pathogenic microorganisms and maintain the low pH environment of the vagina [3-9]. Probiotics play an important role in maintaining the stability of vaginal microenvironment, improving immune defense and blocking the progression of cervical cancer [3-9]. There is an association between a highly diverse vaginal microbiota and female reproductive tract health [3-9]. Probiotics play an important role in maintaining the health of the female reproductive tract, alleviating gynecological diseases, and enhancing the local immunity of the vagina [3-9]. The use of probiotics or VMT intervention has a certain effect on preventing the progression of CIN, treating BV, and relieving symptoms related to senile vaginitis [3-9]. The development of 16SrRNA sequencing technology can help to identify microbial markers and carry out personalized prevention and treatment of diseases [3-9]. At present, the mechanism of action of probiotics in cervical cancer is not fully understood[3-9].

Overall, the administration of intravaginal estrogen and/or probiotics in pre-menopausal ACB women is feasible, safe, and well tolerated [3-9]. Although *Lactobacilli* dominate a healthy vaginal microbiota, another bacterial species with the ability to release lactic acid, *Bifidobacterium*, seems to play a protective role in the vagina as well [3-9]. These bacteria can exist side-by-side with *Lactobacilli*. But reports find *Bifidobacterium*-dominant microbiome in 5-10% of healthy reproductive-aged women, suggesting they could potentially correspond to a new CST [3-9]. Overall, *Lactobacilli* and *Bifidobacteria* are indicators of a healthy vaginal microbiome, but there are limited data to support whether using probiotics to replenish either of these species can improve vaginal health and alleviate infections [3-9]. The application of probiotics is a safe, effective, and natural way to support women's health [3-9]. Incorporating probiotics into a woman's daily routine, either through supplementation or dietary sources, may offer numerous benefits for gynecologic and obstetric health, including preventing STIs and treating vaginal infections, improving metabolic and hormonal profiles in PCOS women, reducing the risk of obstetrics complications such as GDM, maternal GBS colonization, obstetric anemia, and postpartum mastitis, alleviating menstrual pain and endometriosis-related symptoms, and potentially even reducing the risk of certain gynecologic cancers[3-9]. These benefits are likely due to the ability of probiotics to restore and maintain a healthy vaginal microbiome, as well as to modulate the immune system [3-9]. Further research is required to fully understand the action mechanisms of probiotic, although current evidence strongly supports their use in promoting women's health [3-10].

4. Conclusion

Probiotics, live microorganisms that confer health benefits to the host when administered in adequate amounts, have gained considerable attention for their potential role in maintaining women's health. Probiotics regulate the innate and adaptive immune response modulating dendritic cells (DC), macrophages B and T lymphocytes. The most significant barrier associated with probiotics in the food industry is their susceptibility to processing conditions and sensitivity to gastrointestinal (GI) stresses. Consuming probiotic food is more readily acceptable to consumers as it is a more natural way of receiving their daily dose of probiotics. Fruit juices supplemented with probiotics have been reported as a more unique and appropriate method in the probiotic beverage industry. Probiotics also increase the production of anti-inflammatory cytokines while interacting with intestinal epithelial cells and attracting macrophages and mononuclear cells. In gynecologic conditions, probiotics showed potential in preventing and managing bacterial vaginosis, vulvovaginal candidiasis, and sexually transmitted infections. During pregnancy, probiotics may be helpful in reducing the risk of gestational diabetes, maternal group B streptococcal colonization, obstetric anemia, and postpartum mastitis. Overall, *Lactobacilli* and Bifidobacteria are indicators of a healthy vaginal microbiome, but there are limited data to support whether using probiotics to replenish either of these species can improve vaginal health and alleviate infections.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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