

A Review of Current Non-Dairy Probiotic Trends and Consumer Acceptance

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ABSTRACT

Probiotics are live microbe compositions that, when taken in sufficient doses, primarily improve gut and gastrointestinal tract health. Nowadays, consumers are looking for healthy probiotic substitutes since they are increasingly health-conscious. The current analysis highlights the latest advancements and global commercialization of non-dairy probiotic products in various forms while considering the health advantages of probiotics. Dairy probiotics are known to cause lactose intolerance and allergies in their users. The main advantages of non-dairy drinks, particularly fruit juices, are their flavor, nutritional content, and refreshing nature. While probiotic strains from non-dairy sources are tolerated, the various food media of dairy food carriers are the main obstacles to the probiotics' survival. In addition to the viability of the probiotics employed in non-dairy fermented goods, functional and technological features are crucial for achieving small gains in the worldwide market.

Key words: Fruit juices, Microorganisms, Non-dairy, Probiotics, Viability.

Foods are crucial for encouraging a healthy and active lifestyle. The demand for nutritious food is currently the most significant trend in food consumption. Only when a food attempts to have beneficial and desirable effects on specific bodily functions in addition to its traditional sustaining effect can it be classified as functional. Probiotic cultures have been linked to humans since they started eating fermented foods. A French scientist at the Pasteur Institute discovered Y-shaped bacteria in breastfed children, which he termed Bifidiobacteria because they caused fewer gastrointestinal issues (Tissier, 1906). The term "probiotics" was first used by Kollath in 1953 to refer to dietary supplements that were used to augment the diet of undernourished people with both organic and inorganic components. The active ingredients necessary for a healthy life development were referred to as "probiotika" the next year. Lilly and Stillwell broadened the word to include anaerobic microorganisms that create particular acids, such as lactic acid, and promote the growth of other organisms (Lilly and Stillwell, 1965). According to FAO/WHO (2002), probiotics are live microbe compositions that, when ingested in sufficient quantities, primarily improve health by acting on the stomach and gastrointestinal tract. People who are lactose intolerant, allergic to milk proteins, hypercholesterolemic, or strict vegetarians can now consume helpful microbes thanks to the production of non-dairy probiotic food items.

Microorganisms included in probiotics

A variety of lactic acid bacteria (LABs) are known and utilized commercially for preparing probiotic fermented milks across the world (Tamime *et al.*, 2005). Most commonly used genera are *Lactobacillus*, *Lactococcus*, *Leuconostoc*, *Pediococcus*, Department of Microbiology, Punjab Agricultural University, Ludhiana-141 004, Punjab,

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Streptococcus and *Oenococcus* (Pot, 2008). Some of the others include diverse strains from *Lactobacillus acidophilus*, *Lactobacillus casei*, *Lactobacillus paracasei*, *Lactobacillus helveticus*, *Lactobacillus plantarum*, *Lactobacillus gasseri*, *Lactobacillus delbrueckii* subsp. *bulgaricus*, *Lactobacillus johnsonii*, *Lactobacillus reuteri*, *Lactobacillus rhamnosus*, *Bifidobacterium bifidum*, *Bifidobacterium infantis*, *Bifidobacterium breve*, *Bifidobacterium lactis*, *Bifidobacterium longum*, *Bifidobacterium laterosporus* and further species such as, *Streptococcus thermophilus*, *Escherichia coli* Nissle, *Propionibacterium* spp., *Pediococcus* spp., *Weissella* spp., *Enterococcus faecium*, *Leuconostoc* spp. and *Saccharomyces cerevisiae* var. *boulardii* (Nagpal et al. 2012; Patel et al., 2013).

Health benefits conferred by probiotics

Probiotics have a number of positive health effects, including as boosting gut health, lowering blood cholesterol, preventing cancer, and improving immunological response. Probiotics have been shown to be helpful in treating diarrheal illnesses, preventing diarrhea brought on by antibiotic consumption, and improving lactose metabolism. Other advantages include anti-diabetic (Larsen et al., 2010; Grover et al., 2012), anti-obesity (Karimi et al., 2015), anti-inflammatory (Cammara et al., 2016; Spiller et al. 2016), anti-cancer (Awaisheh et al., 2016), anti-allergic (Song et al., 2016), and their effects on the central nervous system. Probiotics have several important mechanisms of action, including increased adhesion to intestinal mucosa and subsequent inhibition of pathogen adhesion, competitive exclusion of pathogenic microbes, production of antimicrobial compounds, and immune system modulation. Secretory IgA antibodies, the mucous layer, the epithelial junction adhesion complex, and antimicrobial peptides are all part of the defense mechanisms of the intestinal barrier (Ohland and Macnaughton, 2010). Few of the elementary mechanisms by which the probiotics present health benefits to the host involve regulating the mucosal hindrance work, diminishing the apoptosis of epithelial cells and by expanding mucin creation (Saad et al., 2013), supporting the expanded creation of antimicrobial peptides like defensins and cathelicidins by host cells (Mondel et al. 2009), balancing the invulnerable framework, by blocking master fiery particles and by expanding mucin creation (Tien et al., 2006) creation of microcins, bacteriocins and other antimicrobial elements that cause the intestinal conditions to be less agreeable for other pathogenic microorganisms (particularly by bringing down pH) (Sharma and Devi, 2014), holding fast in a serious manner to the epithelial cells and by hindering the microorganisms adherence on the epithelial cells either straightforwardly or by implication (Wu et al. 2008) and meddling with the majority detecting flagging, a manner by which the pathogenic microorganisms communicate with each other (Medellin-Peña et al., 2007). Mahewu, Bushera, and Bulgarian boza enhanced with lactic acid bacteria and yeasts are a few examples of traditional fermented drinks (Gotcheva et al., 2002). Retaining viability and sensory qualities are essential for these commodities to perform well in the market (Rouhi et al., 2013). According to Endo et al. (2014), probiotic viability during processing and long-term storage is significantly influenced by the kind of dietary medium/matrix, cell conditions, and moisture content intensity. Figure 1 lists the mechanisms of action of probiotics (Tiwari et al., 2012).

Reasons behind rising popularity of non-dairy probiotics

Since probiotics are recognized to be beneficial to civilization, an incredible new trend of non-dairy probiotics has arisen. Non-dairy probiotic meals have gained international recognition due to the ongoing vegetarianism trend and the extreme prevalence of lactose sensitivity in large civilizations worldwide. Fruit juices, sweets, and probiotic-containing cereal-based items are additional appropriate media for probiotic delivery (Cargill, 2009). In his research on the vacuum-impregnated growth of

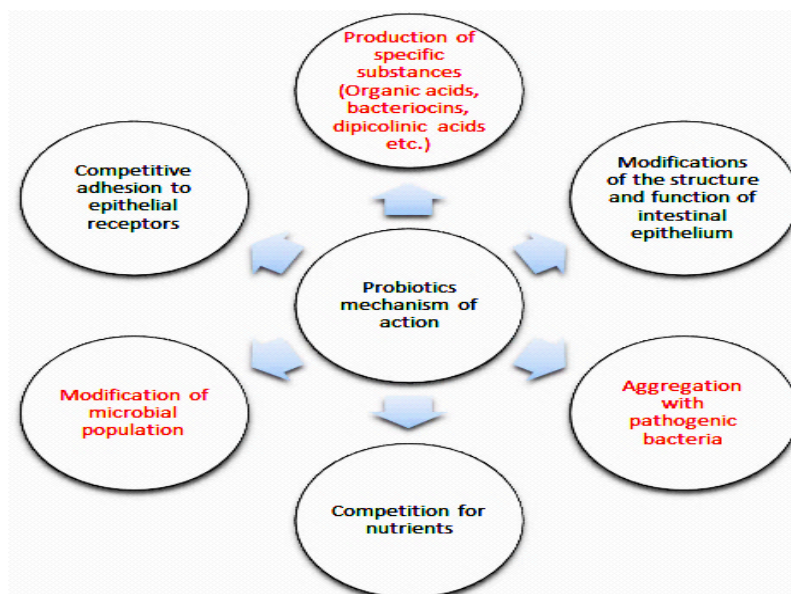


Fig 1: Mechanism of action of probiotics (Tiwari *et al.*, 2012).

Probiotic-enriched dried fruits revealed that specific structural characteristics of fruit and vegetable matrices can be changed through controlled manipulation of their constituents, such as culture media fortification and pH change, employing cutting-edge technology. Lactose intolerance, excessive cholesterol, and certain milk proteins that cause allergies are some of the main restrictions on dairy probiotic usage. These restrictions have led to the development of non-dairy probiotics that get around these restrictions. Non-vegetarian and dairy-based meals make up a relatively small portion of Asian diets, while botanical foods maximize daily food consumption. Asian people are discouraged from consuming milk and associated products due to lactose sensitivity in addition to dietary restrictions.

Potential health risks linked with dairy base probiotic products

Dairy-based probiotic dietary items are associated with certain health risks. They basically include high fat and cholesterol levels, lactose intolerance, and allergic hypersensitivity to milk proteins. Below is an explanation of these health risks:

Intolerance to lactose

It describes a lack of β -galactosidase, which prevents lactose from being hydrolyzed or broken down into the monosaccharides glucose and galactose. The indigested or non-hydrolyzed lactose is broken down by bacterial enzymes un the large intestine, resulting in osmotic diarrhea. When drinking milk and milk products, people who are lactose intolerant have diarrhea, gas, and abdominal pain. Probiotics, especially some strains over others, increase lactose metabolism.

Milk proteins associated allergy

Atopic dermatitis (AD) is a condition that is commonly associated with food allergies in children (Johnke et al., 2007). Reid and Kirjaivanen (2005) found that probiotic ingestion reduces the incidence of atopic dermatitis. Numerous investigations have shown that individuals using particular probiotic strains had fewer symptoms. Additionally, a small number of studies have demonstrated that probiotic supplementation had little effect on the symptoms associated with childhood allergies (Brouwer et al., 2006).

High fat and elevated cholesterol content

The source of milk determines how much fat it contains. Buffalo milk has about 7-8% fat, whereas cow milk has about 4-5% fat. High milk consumption has been shown to be a major risk factor for obesity and cardiovascular disease, and it is predicted to increase the average volume of cholesterol and low density lipoprotein-cholesterol in the blood (Bard et al., 2020). By raising the amount of saturated fat in the diet and lowering the level of low-density lipoprotein (LDL) cholesterol, this risk can be reduced.

Probiotic dosage, viability and preparation

The ability of probiotic strains to survive passage through the upper gastrointestinal system and to colonize and multiply in the human bowel is largely responsible for their health benefits (Bhat et al., 2015). The loss of probiotic endurance is a feature of several audits on probiotics during preparation, storage, and after absorption (Shori 2015). As a result, maintaining the probiotic strain's suitability is crucial for attaining health benefits since the quantity of viable cells that are present when using probiotic food items is what determines their effectiveness (Iravani et al., 2015). A product's colony forming units per milliliter, or cfu/ml, is regarded as a crucial component.

A concentration of 10^8 to 10^9 probiotic microorganisms must be consumed by the consumer for a probiotic effect to be transferred. The probiotic strains should be able to grow in commercial and manufacturing settings and maintain viability under typical storage conditions (Sanders, 2008). Viability, which is by definition necessary for probiotics to work, enhances a number of pathways, including gut permeability reduction, adhesion, and immunomodulation (Kosin and Rakshit, 2006; Sucheta et al., 2018). The aforementioned information was demonstrated by FAO/WHO (2002), which established the requirement that any food product purported to contain a probiotic microbe contain at least 10^6 to 10^7 cfu/mL of viable probiotic bacteria. The crucial phases that affect the viability and survival of probiotics include processing, packing, treatment, and transportation. After ingestion, the probiotics will eventually be able to endure the bile salts of the small intestine and the acidic conditions of the stomach until they reach the lower gastrointestinal system, where they will have positive effects.

Food, environmental and processing parameters like pH, titratable acidity, incubation temperature, water activity, the presence of sugar, salt, and chemicals like H_2O_2 , molecular oxygen, bacteriocin, synthetic flavor, heat therapy, coloring agents, storage methods, packaging materials and conditions, proportion and inoculation intensity, and strain species are important factors that affect the activity and viability of

probiotic cultures (Perricone et al., 2015). In addition to production and storage factors, the stomach's acidity, intestinal enzymes like lysozyme, bile salts, toxic metabolites like phenols produced during digestion, antibiotics, bacteriophages, and anaerobic conditions can all affect the survival of probiotics (Maleki et al., 2015).

Sensory assessment and acceptability of non-dairy probiotic products

Associations between different probiotic strains and food matrices can have an impact on the sensory qualities of non-dairy probiotic products. During storage and processing, the development of particular metabolic compounds like lactic acid and other metabolites in living cells from various organisms can either improve or worsen texture, taste, odor, fragrance, and color (Panghal et al., 2018). Fruit juice that has been probiotified has been described as having "dairy," "medicinal," "acid," "salty," "bitter," "astringent," "artificial," or "earthy" flavors (Luckow & Delahunty, 2004). Depending on the type of product, the probiotic organism, processing temperature, and application of prebiotics and protectants can all affect the generated probiotic juice's sensory qualities (Lebaka et al., 2018). Therefore, during the manufacturing and storage of probiotic non-dairy meals, it is crucial to assess both the successful probiotic survival and the sensory acceptance. Therefore, sensory evaluation of probiotic bacteria in non-dairy meals is important from an industrial standpoint.

Challenges faced by non-dairy probiotic products

To keep the probiotics viable throughout processing and storage, a dietary substrate must be carefully chosen. During the manufacture and storage of fruit, cereal, and vegetable probiotic goods, probiotic stability and survival were found to depend on the variety of probiotic strains as well as the food substrate, water activity, and final product pH. One major problem is the use of probiotic microorganisms in non-dairy meals. Fruit and vegetable juices offer certain vital nutrients, but they also contain certain elements that may make probiotics less viable, such as low pH, which is associated with high quantities of organic acids and dissolved oxygen. Probiotic viability may be severely hampered by room temperature storage, which is common in many non-milk product types.

Non-dairy probiotic products examples

Classification of various kinds of non-dairy probiotic products has been given in figure no. 2 (Kumar et al., 2015).

Cereals

Among the staple meals consumed daily worldwide are cereals including wheat, maize, oats, barley, and other grains with complex nutrient compositions. Cereals include a substantial amount of vitamins, minerals, proteins, carbs, dietary fiber, and oligosaccharides (Kumar et al., 2015). Among the many benefits of cereals include increased access to nutritional minerals like iron, calcium, and phosphorus due to the production of organic acids or microbial enzymes like phytases. Examples of fermented non-dairy beverages made from cereals include Boza, Mahewu, Togwa, and Bushera. *Lactobacillus acidophilus*, *Lactobacillus plantarum*, *Lactobacillus brevis*, *Lactobacillus fermentum*, *Leuconostoc*

renolactis, *Lactobacillus coprophilus*, *Leuconostoc mesenteroides*, *Candida tropicalis*, *Candida glabrata*, *Saccharomyces cerevisiae*, *Geotrichum candidum*, and *Geotrichum penicillatum* are some of the main microorganisms linked to Boza, a fermentation of cereals with sugar.

Lactobacillus brevis predominates. The lactic acid bacteria that were identified from Bushera included *Leuconostoc*, *Lactococcus*, *Streptococcus*, and *Enterococcus* (Heperkan et al. 2014). At normal temperature, the natural microflora of malt ferments spontaneously. The main microbe found in Mahewu is *Lactococcus lactis* subsp. *lactis* (Blandino et al. 2003). Probiotic bacteria like *Lactobacillus plantarum* and *Streptococcus* are used to ferment multi-grains including sorghum, maize, and finger millet flour to create togwa, a fermented beverage from Japan (Panghal et al., 2018).

Fruit and vegetable products

Products of the fruits and vegetables are viewed as sound nourishments and are a perfect matrix for the functional

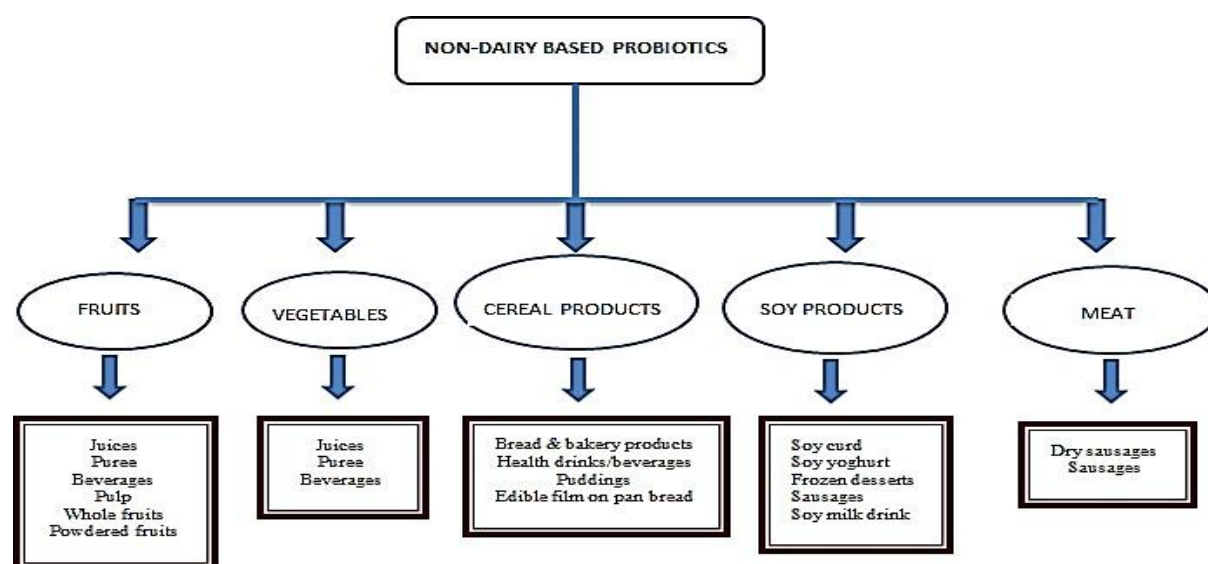


Fig 2: Classification of different non-dairy based probiotic products (Kumar *et al.*, 2015).

components because they include beneficial supplements, such as various phytochemicals, cancer-prevention agents, minerals, nutrients, and dietary fibers (Slavin and Lloyd, 2012). They have a high sugar and nutritional content, which is necessary for the growth of probiotics. When combined with their rapid passage through the stomach's extremely acidic conditions, they provide high probiotic cell viability (Kandylis et al., 2016). Products made from fruits and vegetables are revitalizing, invigorating, healthful, and appealing to all demographics (Panghal et al., 2018). Blackcurrant juice (Luckow and Delahunty 2004), cranberry, pineapple, and orange juices (Sheehan et al. 2007), table olives (De Bellis et al., 2010), cashew apple juice (Pereira et al., 2011), plum juice (Sheela and Suganya, 2012), noni and mulberry juice (Chaudhary et al., 2019), and fruit juices—mango, sapota, and grape (Kumar et al., 2013). Many probiotic fruits and vegetable products have been produced using a variety of probiotic strains, mainly *Bifidobacteria* and *Lactobacillus* species, such as *Lactobacillus acidophilus*, *Lactobacillus paracasei*, *Lactobacillus casei*, *Lactobacillus plantarum*, *Lactobacillus rhamnosus* GG, *Lactobacillus*

fermentum, and *Bifidobacterium bifidum*.

Meat and meat products as probiotics

Additionally, it has been discovered that meat is a great way to give probiotic bacteria. Since fermented sausages are produced without heat treatment and may include probiotic bacteria, they are appealing target meat items with probiotic bacteria (Arihara and Ohata, 2011). The presence of other microorganisms (native meat microflora), pH, acidity, water activity, processing and storage temperature, additive concentration (nitrite and nitrate), salt, protein matrix composition, and low natural sugar content are some of the main technical factors that may affect their growth and viability. *Lactobacillus plantarum*, *Lactobacillus sakei*, *Lactobacillus casei*, *Lactobacillus paracasei*, *Lactobacillus rhamnosus*, *Pediococcus pentosaceus*, and *Pediococcus acidilactici* are the most commonly used species of probiotic microbes in fermented meat products. Probiotic strains have been successfully introduced to a variety of fermented meat products, including fuet, Hungarian salami, Swiss salami, Norwegian salami, Longaniza de Pascua, Salchichón, cured pig loinshe, Italian salami, and mouton fermented sausage, according to several research.

Soy products

Particularly in Asian nations, soybean-based goods like tofu have grown in market share because of its affordability and nutritional value, which includes proteins, oligosaccharides, vitamins, and minerals (Ojokoh and Yimin, 2011). Lactic acid bacteria (LAB), a well-known probiotic bacterium with numerous bioactivities, are the most appropriate and commonly utilized starter strains. Although LAB is primarily associated with dairy products, it also affects other food supplies and processes, including food preservation, drinks, and sausages. A common soy-based beverage is soy milk. According to Shimakawa et al. (2003), probiotic LAB strains like *Lactobacillus casei*, *Lactobacillus paracasei*, *Bifidobacterium*, and *breve Lactobacillus mali* have been found to be effective starters for the fermentation of soy milk, resulting in better fermented soy milk products with a pleasant flavor and bioactivity.

CONCLUSION

It is possible to produce non-dairy probiotic foods, which would allow those who dislike dairy products or who have an allergy or sensitivity to milk ingredients to eat these helpful microbes. Since recent studies have demonstrated the use of strains that are well adapted in alternate substrates, non-dairy probiotic and prebiotic products have a high marketing potential. By researching the population's benefits, non-dairy probiotic product experimentation can be increased. In order to adapt non-milk probiotic food items to the demands of the world's population, it is imperative that a new, affordable, and flexible technical framework be developed. Maintaining the probiotic viability during the goods' shelf life and after consumption in the gastrointestinal tract, as well as preserving the physicochemical and sensory qualities of conventional items, are the two key obstacles encountered during manufacturing. Despite these challenges, non-dairy probiotic products have a bright future.

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