



Current Trends in Non-Dairy Probiotics and Their Acceptance among Consumers: A Review

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10.18805/ag.R-2172

ABSTRACT

Probiotics are defined as formulations of live microorganisms that exert health benefits mainly through their action on gut and gastrointestinal tract when consumed in vital amounts. Consumers have become more health conscious now and they are searching for health probiotic equivalents. Looking upon the health benefits conferred by probiotics, the present review emphasizes the recent developments and commercialization of non-dairy probiotic products in different forms worldwide. Dairy probiotics are known to induce allergy and intolerance to lactose among the consumers. The chief benefits of non-dairy beverages specifically fruit juices are their nutritional values, flavor and refreshing quality. The diverse food mediums of dairy food carriers are the major limitations for the survival of the probiotics whereas the probiotic strains from non-dairy sources are acceptable. In addition to the viability of the probiotics used in fermented products of non-dairy origin, functional and technological characteristics are tremendously vital to get modest benefits in the global market.

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

Foods play an essential role in promoting a fit and healthy life. The prior most and important trend of food consumption these days is the demand for healthy food. The food can be tagged as functional only if it endeavors additional favorable and worthwhile effect on certain body functions besides its traditional sustenance effect. Ever since the humans began consuming the fermented products, the probiotic cultures have been associated with the humankind. A scientist of Pasteur Institute, France reported the presence of Y shaped bacteria in breast fed infants and named it *Bifidiobacteria* which had fewer gastrointestinal problems (Tissier, 1906). Kollath was the first individual to use the word probiotics for those food supplements which were used to enhance the diet with inorganic and organic components for the undernourished (Kollath, 1953). The following year, the same term 'probiotika' was used for the active substances that are essential for a healthy development of life. The term was expanded by Lilly and Stillwell in the form of anaerobic microbes which produce specific acids like lactic acid and enhance the growth of other organisms (Lilly and Stillwell, 1965). Probiotics are defined as formulations of live microorganisms that exert health benefits mainly through their action on gut and gastrointestinal tract when consumed in vital amounts (FAO/WHO, 2002). The production of non-dairy probiotic food products allows the consumption of beneficial microorganisms by persons intolerant to lactose, allergic to milk proteins, hypercholesterolemic, or strict vegetarian.

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*,

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How to cite this article: Natt, S.K. and Katyal, P. (2021). Current Trends in Non-Dairy Probiotics and Their Acceptance among Consumers: A Review. *Agricultural Reviews*. DOI: 10.18805/ag.R-2172.

Submitted: 12-02-2021 **Accepted:** 26-04-2021 **Online:** 21-05-2021

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 offer several beneficial health attributes, some of which include immune response enhancement, serum cholesterol reduction and prevention of cancer and augmentation of intestinal health. There is adequate proof to support the fact that use of probiotics is beneficial in curing diarrheal diseases, prevention of diarrhea caused due to

intake of antibiotics and lactose metabolism. Some of the other benefits comprise anti-diabetic (Larsen *et al.*, 2010; Grover *et al.*, 2012), anti-obesity (Karimi *et al.*, 2015), anti-inflammatory (Camarota *et al.*, 2016; Spiller *et al.* 2016), anti-cancer (Awaisheh *et al.*, 2016), anti-allergic (Song *et al.*, 2016) and their consequence on central nervous system. Augmentation of the epithelial barrier, proliferated adhesion to mucosa of intestine and consequent impediment of pathogen adhesion, competitive exclusion of pathogenic microbes, generation of anti-microbial substances and immune system modulation constitute the significant mechanisms of action of probiotics. Intestinal barrier defense mechanisms involve secretory IgA antibodies, mucous layer, epithelial junction adhesion complex and antimicrobial peptides (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 have 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). Some of the traditional fermented beverages include Bulgarian boza enriched with Lactic acid bacteria and yeasts (Gotcheva *et al.*, 2002), Mahewu and Bushera. The key conditions for the performance of such commodities in the market are retention of viability and sensory characteristics (Rouhi *et al.*, 2013). Endo *et al.* (2014) revealed that, type of food medium/matrix, cell conditions and moisture content intensity play an important part in probiotic survival during processing and storage for long-term. Probiotics mechanism of action has been listed in the Fig 1 (Tiwari *et al.*, 2012).

Reasons behind rising popularity of non-dairy probiotics

A new trend of non-dairy probiotics has emerged amazingly, since probiotics are known to be boonful to civilization. Thanks to the continuing trend in vegetarianism and the exorbitant pervasiveness in lactose sensitivity in broad societies across the world, non-dairy probiotic foods have acquired global prominence. Other suitable media for the delivery of probiotics may be fruit juices, desserts and cereal-based products with probiotics (Cargill, 2009). Betoret *et al.* (2003) in his study on vacuum impregnated development of

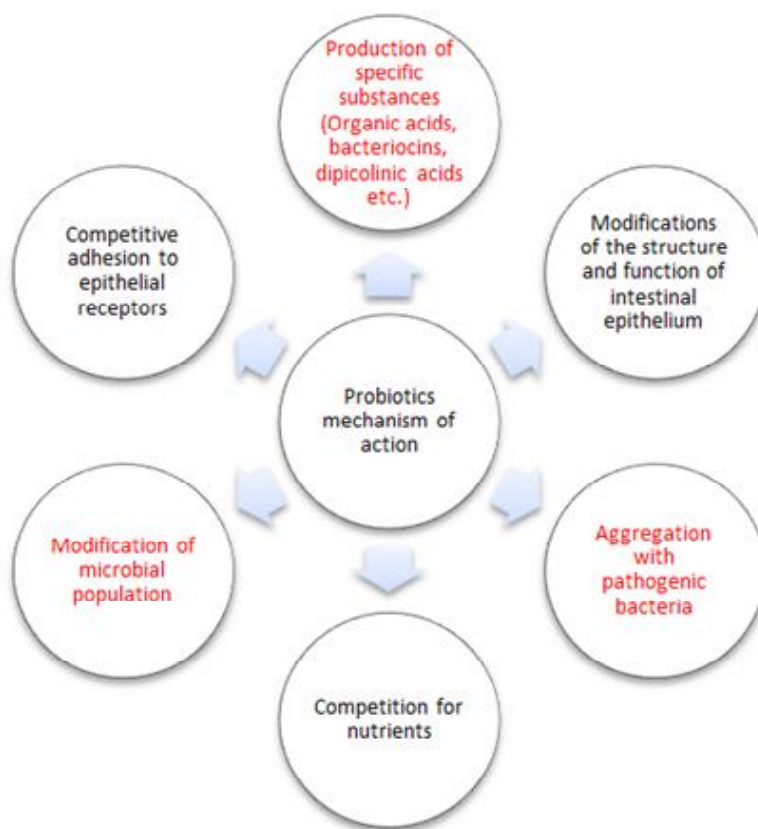


Fig 1: Mechanism of action of probiotics (Tiwari *et al.*, 2012).

probiotic-enriched dried fruits reported that using advanced technologies, certain structural features of fruit and vegetable matrices can be altered by manipulating their constituents in a controlled manner such as pH alteration and culture media fortification. Some of the major limitations of consumption of dairy probiotics include lactose intolerance, high cholesterol levels and some milk proteins that are the causal agents of allergies which pave way for development of non-dairy probiotics which overcome these limitations. Asian diets are comparatively minimal in non-vegetarian and dairy-based foods, while botanical foods make the most of their daily intake of food. In addition to dietary habits, lactose intolerance in the Asian population discourages them from consuming milk and related products.

Potential health risks linked with dairy base probiotic products

Certain health hazards are linked to dairy based probiotic food products. They essentially incorporate intolerance to lactose, allergic hypersensitivity to milk proteins, high fat and elevated cholesterol content. These health hazards are explained underneath:

Intolerance to lactose

It refers to deficiency of β -galactosidase which leads to failure in hydrolyzing or breakdown of lactose into monosaccharides galactose and glucose. When it reaches the large intestine, the indigested or non-hydrolyzed lactose is acted upon by bacterial enzymes which degrade it causing osmotic diarrhea. People who are intolerant to lactose on consuming milk and milk products develop abdominal discomfort, flatulence and diarrhea. Probiotics confer improved lactose metabolism particularly certain strains over the rest.

Milk proteins associated allergy

A disease which is frequently linked to food allergy in children is atopic dermatitis (AD) (Johnke *et al.*, 2007). Reid and Kirjaivanen (2005) determined that the occurrence of atopic dermatitis is lowered by consumption of probiotics. Several reports have documented a reduction in signs and symptoms in patients with specific strains of probiotics. Few research studies have also shown that probiotic supplementation has no major impact on symptoms linked to childhood allergies (Brouwer *et al.*, 2006).

High fat and elevated cholesterol content

The fat content of milk depends on the source from which it is derived. Cow milk comprises approximately 4-5 percent fat, while buffalo milk contains approximately 7-8 percent fat. High levels of milk intake are expected to raise the average volume of cholesterol and low density lipoprotein-cholesterol in the blood and have proved to be a significant risk factor for cardiovascular disease risk and obesity (Bard *et al.*, 2020). This hazard can be minimized by reducing the level of low-density lipoprotein (LDL) cholesterol and increasing the amount of saturated fat in the diet.

Probiotic dosage, viability and preparation

The health advantages of probiotic strains are for the most part subject to their capacity to endure the entry through the upper gastrointestinal tract and ability to colonize multiply in the host intestine (Bhat *et al.*, 2015). Various audits on probiotics during preparing, stockpiling and after absorption feature the loss of probiotic endurance (Shori 2015). Subsequently, the key measure for the efficiency of a probiotic food item is to sustain the suitability of the probiotic strain, which is important for achieving health benefits because the health benefits of probiotic food items are based on the quantity of feasible viable cells present when used (Iravani *et al.*, 2015). Colony forming units per ml or cfu/ml is considered to be an essential factor in case of a product. For a probiotic effect to be transmitted to the consumer, a concentration of 10^8 to 10^9 probiotic microbes must be ingested by the consumer. The probiotic strains must perpetuate viability in normal storage conditions and should be able to grow under commercial and manufacture conditions (Sanders, 2008). Several mechanisms like gut permeability reduction, adhesion and immunomodulation are potentiated by viability which by definition is a requirement for functionality of probiotics (Kosin and Rakshit, 2006; Sucheta *et al.*, 2018). FAO/WHO (2002) exemplified the above mentioned details that developed the prerequisite that any food product reported to have a probiotic microorganism should encompass at least 10^6 to 10^7 cfu / mL of viable probiotic bacteria. Processing, packaging, treatment, transport are the key stages that influence the probiotic viability and survival. Eventually, upon consumption, the probiotics will be able to withstand both the acidic states of the stomach and the bile salts of the small intestine until they enter the lower gastrointestinal tract where they provide favorable effects. Key factors influencing the probiotic cultures activity and viability involve food, environmental and processing criteria like pH, titratable acidity, incubation temperature, water activity, existence of sugar, salt and chemicals such as H_2O_2 , molecular oxygen, bacteriocin, synthetic flavor, heat therapy, coloring agents, storage techniques, packaging materials and conditions, proportion and inoculation intensity and types of species of strains (Perricone *et al.*, 2015). Survival of probiotics may be also influenced by the acidity of stomach, enzymes like lysozyme existing in the intestine, bile salts, toxic metabolites comprising phenols generated during process of digestion, antibiotics, bacteriophage and anaerobic conditions apart from the production and storage aspects (Maleki *et al.*, 2015).

Sensory assessment and acceptability of non-dairy probiotic products

The sensory characteristics of non-dairy probiotic products can be affected by associations amongst various probiotic strains and food matrices, where texture, taste, odor, fragrance and color can be enhanced or exacerbated through the development of specific metabolic compounds

like lactic acid and other metabolites in living cells from different organisms during storage and processing (Panghal *et al.*, 2018). Probiotification of fruit juice has been reported to result in flavors identified as “dairy,” “medicinal” “acid,” “salty,” “bitter,” “astringent,” “artificial” or “earthy” (Luckow and Delahunty, 2004). The probiotic organism, its processing temperature and the application of protectants and prebiotics, the sensory characteristics of the developed probiotic juice can be influenced depending on the type of product (Lebaka *et al.*, 2018). It is therefore essential to evaluate not only the successful probiotic survival, but also the sensory acceptance during the processing and storage of probiotic non-dairy foods. Hence, Sensory assessment of probiotic microorganisms in non-dairy foods is of crucial industrial significance.

Challenges faced by non-dairy probiotic products

Selection of a food substrate is essential to maintain the probiotic viability in the course of processing and storage. Probiotics stabilization and survival during the development and storage of fruit, cereal and vegetable probiotic products revealed to rely not only on the food substrate, water activity and final product pH, but also on the variety of the probiotic strains. The use of probiotic cultures of non-dairy foods is a significant issue. While vegetable and fruit juices provide certain important nutrients, some factors exist there which might hinder viability of probiotics, like low pH correlated with elevated levels of organic acids as well as dissolved oxygen. Storing at room temperature, typical in numerous kinds of non-milk products, may pose a major challenge for viability of probiotics.

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

Cereals like wheat, maize, oat, barley in addition to other grains, which have intricate composition of nutrients, are among the staple foods consumed every day in the world. A significant quantity of vitamins, minerals, carbohydrates, proteins, dietary fiber as well as oligosaccharides is offered by cereals (Kumar *et al.*, 2015). Cereals confer several advantages out of which a few are rise in the accessibility of nutrient minerals like phosphorous, calcium and iron, by the action of microbial enzymes like phytases or the organic acids produced. Cereal based fermented non-dairy beverages produced examples are Boza, Mahewu, Togwa and Bushera. Some of the major microorganisms associated with Boza, a fermented cold beverage obtained fermentation of cereals like rye, wheat, maize and millets with sugar are *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*. Predominantly *Lactobacillus brevis*, *Leuconostoc*, *Lactococcus*, *Streptococcus* and *Enterococcus* were some of the lactic acid bacteria isolated from Bushera (Heperkan *et al.* 2014). Malt's natural microflora undergoes spontaneous fermentation at room temperature. *Lactococcus lactis* subsp. *lactis* is the chief microorganism isolated from Mahewu (Blandino *et al.* 2003). Togwa is a Japanese fermented beverage produced by fermenting multi-grains like sorghum, maize and finger millet flour with probiotic bacteria like *Lactobacillus plantarum* and *Streptococcus* (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

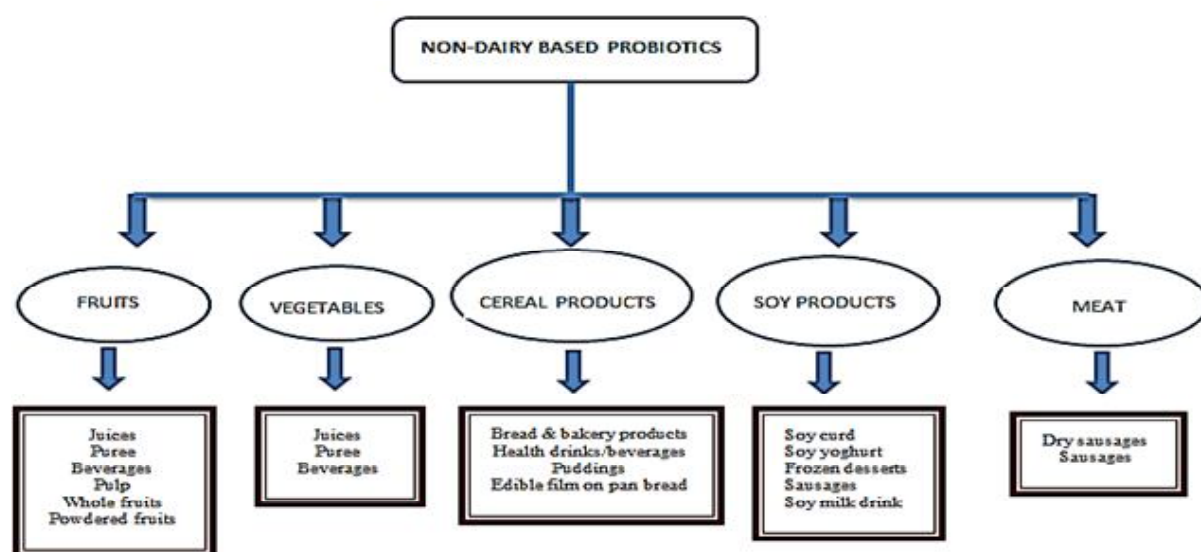


Fig 2: Classification of different non-dairy based probiotic products (Kumar *et al.*, 2015).

ingredients as they contain a helpful supplements, for example, different phytochemicals, cancer prevention agents, minerals, nutrients and dietary fibers (Slavin and Lloyd, 2012). They contain high sugar and nutrient content that is essential for growth of probiotics and result in high probiotic cell viability in amalgamation with the quick passage through the severe acidic conditions of the stomach (Kandylis *et al.*, 2016). Fruit and vegetable products are reviving, refreshing, healthy and have an engaging flavor and taste for all types of population (Panghal *et al.*, 2018). Kimchi is popular as fermented cabbage, blackcurrant juice (Luckow and Delahunty 2004), vegetable-based drinks (Lambo *et al.* 2005), 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), fruit juices - mango, sapota, grape (Kumar *et al.*, 2013) are some of the popular vegetable and fruit based probiotic drinks. Wide range of probiotic strains, primarily *Bifidobacteria* and *Lactobacillus* species, like *Lactobacillus acidophilus*, *Lactobacillus paracasei*, *Lactobacillus casei*, *Lactobacillus plantarum*, *Lactobacillus rhamnosus* GG, *Lactobacillus fermentum* and *Bifidobacterium bifidum* have been commonly utilized in the production of many probiotic fruits and vegetable products.

Meat and meat products as probiotics

Meat has also been found to be an ideal medium for delivering probiotic bacteria. Fermented sausages are attractive target meat products with probiotic bacteria, as these products are manufactured without heat treatment and probiotic bacteria may live in the final product (Arihara and Ohata, 2011). A few of the major technical factors that may influence their growth and viability involve pH, acidity, existence of other microorganisms (native meat microflora), water activity, temperature for processing and storage, additive concentration (nitrite and nitrate) and salt, protein matrix composition and low content of natural sugars. In fermented meat products, the most frequently utilized species of probiotic microorganisms are: *Lactobacillus plantarum*, *Lactobacillus sakei*, *Lactobacillus casei*, *Lactobacillus paracasei*, *Lactobacillus rhamnosus*, *Pediococcus pentosaceus* and *Pediococcus acidilactici*. Numerous studies have shown that probiotic strains have been successfully added to various fermented meat products such as fuet, Hungarian salami, Swiss salami, Norwegian salami, Longaniza de Pascua, Salchichón, cured pork loinshe, Italian salami and mouton fermented sausage.

Soy products

Soybean-based products, such as tofu, have increased their market share due to low cost and nutritional richness (including proteins, oligosaccharides, vitamins and minerals), especially in Asian countries (Ojokoh and Yimin, 2011). The most suitable and widely used starter strains are lactic acid bacteria (LAB), a well-known probiotic bacterium with many bioactivities. LAB is mostly related to

dairy products, but it also plays a role in other food sources and processes, such as sausages, beverages, food preservation, etc. Soy milk is a popular soy based drink. Probiotic LAB strains such as *Lactobacillus casei*, *Lactobacillus paracasei*, *Bifidobacterium* and *breve Lactobacillus mali* are identified as efficient starters for the fermentation of soy milk to produce improved fermented soy milk products with a good taste and bioactivity (Shimakawa *et al.*, 2003).

CONCLUSION

The production of non-dairy probiotic foods is feasible, enabling such beneficial microorganisms to be consumed by individuals that don't like dairy foods or who have an aversion or allergy to milk ingredients. Non-dairy probiotic and prebiotic products have a strong marketing potential, as current researches have shown the application of strains that are well suited in alternative substrates. Experimentation of non-dairy probiotic products can be expanded by studying their benefits to population. Developing fresh, cost-effective and adaptable technical framework is an incredible requirement for adapting non-milk probiotic food products to their demands with global population. During manufacture there are two major challenges posed; maintaining the probiotic viability during the shelf life of the goods and after consumption to the gastrointestinal tract and preservation of the physicochemical and sensory properties of traditional products. In spite of the obstacles, non-dairy probiotic products hold a fairly promising future.

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