

# CURRENT DEVELOPMENT IN NON-DAIRY PROBIOTIC BEVERAGE: AN ASSOCIATED HEALTH BENEFITS

## Abstract

Probiotics are live microorganisms that provide beneficial health benefits to the host when administered in appropriate amounts. Yogurt and fermented milk are two common ingredients in modern probiotic solutions. However, there is an increasing need for probiotic choices that are geared for vegetarians due to the growing vegetarianism trend among consumers in industrialized countries. Considering the information mentioned earlier, cereals, legumes, fruits, and vegetables hold the potential to serve as substrates for beneficial probiotic bacteria colonization. This applies to both developing and developed countries. The non-dairy probiotic beverages' ingredients may present particular difficulties for the survival of the health-promoting microorganisms. Therefore, strain selection and product protection strategies are crucial in creating a stable product to address these issues. Additionally, it looks at the most recent advancements in probiotic beverage with an emphasis on the good viability cell count in the finished product. This review covers non-dairy probiotic drinks, ideal beverage qualities, and popular probiotic strains. The objective of this review is to highlight research focusing on probiotic drinks sourced from non-dairy origins. These non-dairy probiotic beverages offer a suitable option for individuals with lactose intolerance and can also serve as a nutritious alternative to dairy-based probiotics.

**Keywords:** probiotic; non-dairy beverage; microorganisms

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## I. INTRODUCTION

Probiotic is a relatively new phrase that means “for life,” and refer to microorganisms that have positive effects on both people and animals (Hotel and Cordoba, 2001). An Expert Committee’s scientific definition of the term “probiotic” is “live microorganisms that, when consumed in specific amounts, have health benefits beyond those basic nutrition” and it can be consumed either in the form of food components or as non-food preparation (Guarner and Schaafsma, 1998). This requires that the microorganisms be active and abundant, often more than  $10^9$  cells per daily dose and each product should provide the daily dosage needed to bestow any desired health benefit(s). Although not solely, the probiotic bacteria primarily comprise of strains from the genera *Lactobacillus* and *Bifidobacterium* species (Table 1) and have been used since recorded history in the manufacture of fermented dairy products (Gorbach, 2002). However, because of their positive impact on health, species from the genera *Lactococcus*, *Enterococcus*, *Saccharomyces*, and *Propionibacterium* are also taken into account (Balandino et al., 2003; Sanders and Huis in’t Veld, 1999; Vinderola and Reinheimer, 2003). The adult gastrointestinal tract is home to more than 500 distinct bacterial species (Alvarez-Olmos and Oberhelman, 2001; Pham et al., 2008; Bengmark, 1998). While certain bacteria are considered to be advantageous to the human host and others are pathogenic. The gut flora is typically kept in balance, but antibiotics, immunosuppressive drugs, surgery, and radiation therapy can increase the amount of harmful bacteria and upset this equilibrium. The microbial equilibrium in the gastrointestinal system may be restored with probiotics, which contain beneficial bacteria and yeast (Williams, 2010). Probiotics need to have specific characteristics and must able to withstand passage through the digestive system: acid and bile resistance; adhesion to human epithelial cells; colonization in the human gastrointestinal tract; manufacture of antibacterial chemicals (bacteriocins); non-pathogenic and GRAS (Generally Regarded As Safe); favorable growth qualities and benefits to human health (Figure 1) and possesses some desirable characteristics that is low cost, maintain of viable cell count during processing and storage, application capability in the products, physicochemical processing of the food resistance (Prado et al., 2008). Therefore, in this book chapter reviews the recent various non-dairy probiotics based product available on worldwide based on fruits and vegetables, cereal and legumes, soy and other non-dairy based products.

**Table 1: Microorganisms Used as Probiotics in Products (Prado et al., 2008; Williams, 2010; Holzapfel et al., 2001)**

<i>Lactobacillus</i> species	<i>Bifidobacterium</i> species	Other species
<i>L. rhamnosus</i>	<i>B. animalis</i>	<i>Bacillus cereus</i>
<i>L. casei</i>	<i>B. lactis</i>	<i>Enterococcus faecalis</i>
<i>L. paracasei</i>	<i>B. bifidum</i>	<i>Enterococcus faecium</i>
<i>L. plantarum</i>	<i>B. adolescentis</i>	<i>Escherichia nissle</i>
<i>L. acidophilus</i>	<i>B. breve</i>	<i>Streptococcus thermophilus</i>
<i>L. delbrueckii</i>	<i>B. infantis</i>	<i>Saccharomyces boulardii</i>
<i>L. fermentum</i>	<i>B. longum</i>	<i>Clostridium botyricum</i>
<i>L. reuteri</i>		<i>Escherichia coli</i>
<i>L. bulgaricus</i>		<i>Lactococcus lactis</i> sp.cremoriss
<i>L. crispatus</i>		<i>Lactococcus lactis</i> sp. <i>lactis</i>

<i>L. gasseri</i>		<i>Leuconostocmesenteroidessp. dextranicum</i>
<i>L. johnsonii</i>		<i>Pediococcusacidilactici</i>
<i>L. amylovorus</i>		<i>Propionibacterium freudenreichii</i>
<i>L. helveticus</i>		<i>Streptococussalivariusssp. thermophilus</i>
<i>L. lactis</i>		<i>Bacillus coagulans</i>
<i>L. gallinarum</i>		<i>Weissellakimchii</i>
<i>L. helveticus</i>		<i>Sporolactobacillusinulinus</i>
		<i>Saccharomyces cerevisiae</i>

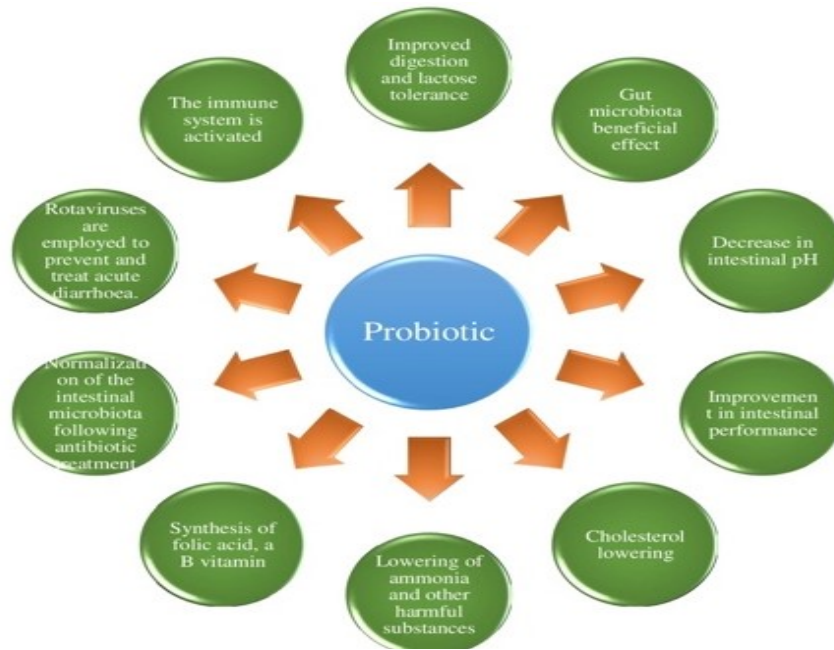
## II. NECESSITY OF NON-DAIRY PROBIOTICS

The majority of probiotic meals now on the market are milk-based, but customers now prefer botanical nutritional supplements that are either cholesterol-free or contain very little cholesterol. The functional food business in the United States is evolving differently than in Europe, with its functional food sector more generally characterized as nutraceuticals and consumer interest centered on botanical dietary supplements rather than food fortification. This trend draws attention to the aforementioned fact. However, as awareness of immunity, cancer, and heart health increases, this pattern is shifting. Additionally, the market for functional foods is still emerging in many countries, although product innovation is seen across a wide range of industries, including beverages, baking, and probiotics, with trends often mirroring those in the United Kingdom and the United States (Vasudha and Mishra, 2013).

The majority of the daily intake in Asian diets comes from plant-based meals, which are relatively low in meat and dairy products. In addition to eating patterns, lactose sensitivity prevents many Asians from drinking milk. The key dairy markets have shown differing amounts of dairy consumption per person during the last decade. The average yearly consumption in China was 10.2 kg, while in India it was 71.8 kg. Similarly, Indonesia had 7.8 kg, Japan had 97.6 kg, Malaysia had 67.8 kg, the Philippines had 24 kg, South Korea had 80 kg, Thailand had 28.7 kg, and Vietnam had 8.6 kg. These values include fluid milk, butter, cheese, nonfat dry milk, and whole milk powder, among other dairy products. This contrasts sharply with per capita consumption rates of 251 kg in the US, 330 kg in the EU-15, and 310 kg in Australia (Dong, 2006). Considering above, cereals, fruits, and vegetables may be suitable substrates for beneficial bacteria (probiotic) to establish themselves, both in developing and industrialised countries.

## III. EFFECT OF PROBIOTICS ON HEALTH

Some of the probiotic health benefits were discussed below:



**Figure 1:** Health Beneficial Effects of Probiotic (Prado et al., 2008)

- 1. Prevention of Diarrhea:** Diarrhoea is frequently accompanied by a disruption in the microbial balance of the gastrointestinal tract. Probiotics have received clinical interest for their potential therapeutic use in the treatment of diarrhoea since they are beneficial microbes for host health. *Lactobacillus*, *Bifidobacterium* and *Saccharomyces* are the probiotics for diarrhoea that have been the most well investigated. Efficacy for treatment for mild to moderate infectious diarrhoea may be specific. For instance, *S. boulardii* and *Lactobacillus* GG may help rotavirus-related diarrhoea, whereas *L. paracasei* has no such effect (Yan and Polk, 2006).
- 2. Stimulation of the Immune System:** Many researchers have investigated on immune system function by effect of probiotic cultures have found that probiotic bacteria can boost both acquired immunity and innate by enhancing phagocytosis and natural killer cell activity, cytokine profiles modification, and increases immunoglobulin levels. The bacteria *B. lactis* and *L. rhamnosus*, both of which are two strains of probiotic that have been developed with the aim of improving immune responses. Many research investigations suggest that both strains increase the normal immune response of healthy persons (Fuller et al., 2008).
- 3. Inflammation of the Bowels:** Ulcerative colitis and crohn's disease are two overlapping phenotypes that leads to inflammatory bowel disease (IBD), mostly affect the colon and small intestine. The disease's cytology is unknown, but normal gut microbiota and genetic predisposition are likely to play essential roles. Changing the composition and activity of the normal microflora may help to alleviate the condition (Ouweland et al., 2002). Some selective probiotics have been shown to lower the incidence of relapses and lengthen the period of remission. Apart from lactic acid bacteria (*L. salivarius* (UCC118) and *L.*

*rhamnosus* GG) , microorganisms like *S. cerevisiae* (*boulardii*) and an *E. coli* strain (Nissle), have also been reported in reducing IBD symptoms.

4. **Intolerance to Lactose:** The primary carbohydrate in milk is lactose. In people with low levels of the intestinal enzyme beta-galactosidase (lactase), the lactose (disaccharide) can result in significant distress in intestinal marked by gas, bloating and abdominal pain. The usage of dairy products is highly restricted due to this illness. It restricts the consumption of calcium-rich foods when they are vitally needed due to bone loss in the elderly people because the disease tends to get worse with age. *Lactobacilli* generate lactase during fermentation, which hydrolyzes lactose in dairy products into glucose and galactose. Lactase is continually produced throughout yoghurt fermentation (Goldin, 1998). Lactose-intolerant subjects who were given fermented milk had much lower hydrogen levels in their breath than those who were given unfermented milk. A sign of lactose digestion by bacteria in the larger intestine is hydrogen in the breath. Lower hydrogen levels indicates that lactose has already been metabolized before reaching the large intestine (Kim and Gilliland, 1983). Probiotics is claimed to improve lactose metabolism, and it appears to involve some strains more than others and in particular concentrations, for instance, yoghurt preparations by conventional method using *S. thermophilus* and *L. delbrueckii* sp. *bulgaricus* are even more effective in this direction, partly due to higher beta-galactosidase activity (Kechagia et al., 2013).
5. **Allergies:** Recent research suggests that early exposure to bacteria may have a protective role against allergy, and probiotics may provide a safe alternative to microbial stimulation that teenaged children's growing immune systems require and improve the function of mucosal barrier, which is responsible for alleviating allergic response. Children and newborns with allergies and those without them, shows quantitative and qualitative differences in their intestinal microbiota, with the former showing adult-like type of microflora colonisation. This supports the function of intestinal microbiota in allergy (Marteau et al., 2002; Salminen et al., 1998; Kalliomäki et al., 2001; Ouwehand et al., 2001). However, a small variety of strains have been evaluated because they are effective in treating and preventing of newborn allergies. In a recent research of breast-fed infants with atopic eczema, *B. lactis* and *L. rhamnosus* GG were found to be useful in reducing the severity of the eczema (Isolauri et al., 2000). However, probiotics have not proved very effective in relieving asthma symptoms (Wheeler et al., 1997).
6. **Cancer:** It has been noted that diets, particularly those high in meat and fat or low in fibre, alter the composition of the intestinal microflora, resulting in higher levels of *Bacteroides* and *Clostridium* and lower levels of *Bifidobacterium* (Benno, 1991). An increase in faecal enzyme activity, including beta-glucuronidase, urease, azoreductase, glycocholic acid reductase and nitroreductase, is linked to this change in microflora composition. These enzymes turn procarcinogens into carcinogens, raising the risk of colorectal cancer as a result. This faecal enzyme activity has been seen to decrease when certain lactobacilli are consumed. However, the majority of epidemiological studies—but not all of them—indicate that consuming fermented dairy products on a regular basis may reduce the chance of developing some types of cancer (Hirayama and Rafter, 2000).
7. **Respiratory Tract Infections:** In animal models, effects of probiotic on the respiratory system that include reducing allergic airway reactions and defending against respiratory

infections have been shown. While dendritic cells appear to be important in guiding the beneficial immune response to probiotic microbes and in translating microbe signals from the innate to the adaptive immunity system, regulatory T cells have emerged as potentially key effects of probiotic-mediated responses, in particular for the reduction of allergic inflammation. Despite advancements in basic research, probiotics' performance in clinical studies for allergy/asthma and respiratory infections has been at best highly unpredictable, which has undermined trust in this prospective therapeutic approach (Vasudha and Mishra, 2013).

- 8. Constipation:** Among the most typical digestive issues among elderly people, especially those who are institutionalised, is constipation. Adults and hospitalised patients who are generally healthy may also experience constipation. Probiotics have been proposed as a treatment for constipation (Lee et al., 1999; Goldin, 1998). Constipated people have a changed faecal microflora, with lower amounts of *Bifidobacteria*, *Bacteroides*, and, in particular, clostridia (Shimoyama et al., 1984). Correcting the microflora composition may not assist because the altered microflora composition is more likely to be a main factor for constipation symptom.
- 9. High Cholesterol:** Many human studies have shown contradictory findings regarding the impact of cultured dairy products or probiotic microbes on cholesterol levels. According to Pereira and Gibson (2002), fermented milk containing both *E. faecium* and *S. thermophilus* reduced total cholesterol as well as LDL in patients with primary hypercholesterolemia.
- 10. Improve Skin Health:** Probiotic bacteria can promote skin health by *in vivo* oral consumption or *in vitro* topical application. Many studies on oral consumption have been conducted in recent years. Probiotics may have skin-protective or skin-healing properties (Roudsari et al., 2015). It has been discovered that taking probiotic bacteria orally can benefit both damaged and healthy skin (Holma et al., 2011). According to research on the skin health advantages of probiotics, oral ingestion may reduce skin irritation and improve the skin's immune function. In one clinical trial, taking a *L. johnsonii* supplement orally for six weeks appeared to speed up the recovery of the skin's immune system when compared to a placebo (Gueniche et al., 2009), while another study found that combining *L. paracasei* and *B. lactis* reduced neuro sensitivity in women with reactive skin (Gueniche et al., 2007). Oral ingestion of probiotic bacteria has been discovered to be a novel strategy to protecting the skin immune system against UV radiation. Some effects have been recorded in hairless mice, and dietary supplementation with *L. johnsonii* has been shown to protect the cutaneous immune system from the immunosuppressive effects of ultraviolet B radiation (Guéniche et al., 2006). Hou et al. (2000) had also reported that during a 48-hour fermentation in soymilk, two bifidobacteria strains (*B. infantis* CCRC 14633 and *B. longum* B6) were found to boost riboflavin levels. Probiotic bacteria applied to the skin may operate as a protective shield and similar to a physical barrier. This bacterial interference is assumed to hinder colonisation by other, potentially pathogenic, bacterial strains by competing inhibition of binding sites (Roudsari et al., 2015).

#### IV. PROBIOTIC NON-DAIRY BEVERAGE

**Table 2: Some recent development in non-dairy probiotic beverage**

Category	Products	Probiotic strains	Results	References
Vegetables and fruits	Apricot based drink	<i>L. rhamnosus</i>	Probiotic count of treatment (T <sub>2</sub> ) shows highest with 6.56 log colony form unit (CFU)/mL on 28 <sup>th</sup> day at 4 <sup>o</sup> C.	Bashir et al. (2023)
	Kombucha drink with butterfly pea flower	<i>L. plantarum subsp. plantarum</i>	Viable count with 6.26 log CFU/mL when stored at 4 <sup>o</sup> C for 28 days.	Majid et al. (2023)
	Snake fruit juice	<i>L. plantarum subsp. Plantarum</i> Dad-13	Viable cell count was $2.7 \times 10^8$ with pH 3.77 and 0.33% total acid (24 h fermentation).	Alwi et al. (2023)
	Pineapple and sorrel juice	<i>L. paracasei</i> 62L	After 30 days of storage (30 °C) and 27 days (4 °C), the viability cell count of <i>L. paracasei</i> 62L was greater than 50%.	Marius et al. (2023)
	Cupuassu juice	<i>L. plantarum</i> Lp62	Probiotic strain remain viable at refrigeration condition, acidic environment and survive gastrointestinal transit <i>in vitro</i> and exhibited 30% adhesion to HT-29 intestinal cells.	da Silva et al. (2023)
	White finger millet based beverage	<i>L. rhamnosus</i> GG (LGG)	Phenolic content increases and viable count was 8.31 log CFU/mL greater than control (7.76 log CFU/mL).	Meena et al. (2023); Navyashree et al. (2022); Byresh et al. (2022)
	Pomegranate drink	<i>L. plantarum</i>	Juice with probiotic strain shows more effective since rich in	Naeem et al. (2023)

			phenolic content and fermentation of juice.	
	Peach based beverage	<i>L. casei</i>	The probiotic count and total plate count ranged from 29 -12.68 CFU/mL and 5.27 - 9.83 CFU/mL, respectively.	Parveen and tul Ain (2023)
	Whole grape juice drink	Lactic acid bacteria(LAB)	Viability of strain at 14 days storage had 7.5 log CFU/mL.	Santos et al. (2023)
	Guava crystal juice probiotic drink	<i>L. casei</i>	Fermentation for 28 h shows optimum result with 9.09 log CFU/mL viable cell count.	Rosidaand Yusuf (2022)
	Dry coconut pulp synbiotic drink	<i>L. casei</i>	Observed increase in phenolic and antioxidant and after 28 days storage the viability at intestinal phase and gastric phase were 4.75 log CFU/mL and 5.90 log CFU, respectively.	Cunha Júnior et al. (2022)
	Fermented beverage enriched with pea and rice protein	LAB	After 143 days of storage the viability was 8.4 log CFU/mL.	Allahdad et al. (2022)
	Passion fruit drink	<i>L. rhamnosus</i> GG (LGG)	Viability was above 10 <sup>7</sup> CFU/mL throughout 28 days storage.	Miranda et al. (2022)
	Gac fruit juice	<i>L. paracasei</i> CASEI 431	Fermentation increases beta-carotene, organic acid and antioxidant activity. Fermented Gac juice (FGJ10) showed highest viability (8.38 log/CFU/mL).	Marnpae et al. (2022)
	Fermented mango juice	<i>S. thermophilus</i> ; <i>B. acidophilus</i> ; <i>L. acidophilus</i> ;	<i>L. rhamnosus</i> GR-1 indicated the highest cell count of log <sub>10</sub> 9.14	Mwanzia et al. (2022)



		<i>L. delbruijkissp bulgaricus</i> ; <i>S. thermophilus</i> ; <i>L. rhamnosus</i> GR-1	CFU/mL for 48 h.	
Mangoste en juice		<i>L. casei</i> (TISTR 390); <i>L. fermentum</i> (TISTR 391); <i>L. plantarum</i> (TISTR 1463)	Probiotic mangosteen juice had stronger antioxidant activity than control mangosteen juice (72 h), which had lower IC50 values.	Mongkonta nawat et al. (2022)
Mango juice drink		<i>L. acidophilus</i> La-5	Probiotic viability increased with addition of 10% mango juice; improve probiotic tolerance in vitro gastrointestinal digestion.	Ryan et al. (2020)
Orange juice beverage		<i>P. acidilactici</i> (CE5 1)	After 35 days at 40 <sup>0</sup> C and 30 <sup>0</sup> C, the probiotic cell count was found to be 7.2 and 8.5 log CFU/mL.	de Oliveira Vieira et al. (2020)
Passion fruit probiotic drink		<i>L. reuteri</i>	Optimal condition was found to be 30 <sup>0</sup> C at pH 3.18 (5.59 × 10 <sup>11</sup> CFU/mL).	Santos Monteiro et al. (2020)
Pineapple and whey juice		<i>L. acidophilus</i> (LA-5)	The beverage's viable probiotic cell counts were 4.92 log <sub>10</sub> CFU/mL after 42 days and 4.20 log <sub>10</sub> CFU/mL after 56 days, respectively.	Islam et al. (2021)
Pumpkin juice		<i>L. casei</i> (431)	The survivability test revealed that after 13 days in the refrigerator, the culture still had more than 10 <sup>6</sup> CFU/mL.	Dimitrovski et al. (2021)
Mango juice		<i>L. acidophilus</i>	For up to 28 days, probiotic viability in probiotic mango juice produced at the pilot plant size was greater than 8 log CFU /mL.	Dhillon et al. (2021)
Pineapple		<i>L. casei</i>	24 h fermentation	Rahayu et

skin drink		shows best result	al. (2021)
Passion fruit and yam flour beverage	<i>L. casei</i>	Viability cell count was greater than $10^6$ CFU/mL and resist the gastrointestinal system environment ( $> 10^4$ CFU/mL).	GUEDES et al. (2021)
Fortified orange-nettle drink	<i>L. rhamnosus</i> (ATC C 53103)	During 28 days of storage at 40°C, <i>L. rhamnosus</i> population size ranged from 6.77 to 7.33 log CFU/mL.	Sengun et al. (2020)
Pineapple juice	<i>B. lactis</i> (Bb-12); <i>L. plantarum</i> (299V); <i>L. acidophilus</i> (La5)	After 24 hours of fermentation, there were $5 \times 10^9$ CFU/mL of <i>Lactobacilli</i> and $10^9$ CFU/mL of <i>Bifidobacteria</i> , respectively.	Nguyen et al. (2019)
Sohiong juice	<i>L. plantarum</i> (MCC 2974)	Viable cell increased to more than 6 log CFU/mL after four weeks of storage at 40°C and up to 10 log CFU/mL after 72 hours at 37°C.	Vivek et al. (2019)
Vegetable (Jicama, winter melon and carrot) mixture juice	<i>L. plantarum</i> (CICC22696); <i>L. acidophilus</i> (CICC20710)	At 28 days storage (4°C) the viability of <i>L. plantarum</i> was around 8 log CFU/mL, whereas the viability cell count of <i>L. acidophilus</i> was only 4.57 log CFU/mL.	Do and Fan (2019)
Beet juice	<i>L. plantarum</i> ; <i>L. paracasei</i>	Viability count of <i>L. plantarum</i> and <i>L. paracasei</i> increased to 9.03 log CFU/mL and 9.69 log CFU/mL, respectively during 42 days cold storage (4°C).	Jafar et al. (2019)
Ready to drink ice tea	<i>L. acidophilus</i>	After reconstitution, ready-to-drink tea and spray dried premix	Tewari et al. (2018)

			viability count were 10.03 log CFU/mL and 9.98 log CFU/mL, respectively.	
Breadfruit flour beverage	<i>L. acidophilus</i> ; <i>L. plantarum</i> (DPC 206); <i>L. casei</i>		The combination of three strain after 72 h fermentation shows highest (8.106 log <sub>10</sub> CFU/mL)	Gao et al. (2019)
Pomegranate juice	<i>L. acidophilus</i>		No bacteria was detected after second week of storage (4 <sup>0</sup> C)	Ghazavi and Abedi (2018)
Mulberry-whey beverage	<i>L. delbrueckii</i> subsp. <i>bulgaricus</i> ; <i>S. thermophilus</i> ; <i>L. rhamnosus</i> GG		Sweet whey and black mulberry juice (SWBM3) with <i>L. rhamnosus</i> possessed 7.88 log CFU/mL viable cell count when stored for 21 days at 4 <sup>0</sup> C.	AbdulAlim et al. (2018)
Orange-whey based RTS beverage	<i>L. fermentum</i> PH5		Viability cell count of formulated blend (B2) and control (C) are 6.10 log CFU/mL :7.25 log CFU/mL when stored for 28 days at 7 <sup>0</sup> C.	Thakkar et al. (2018)
Ready-to-drink beverage (Ber fruit)	<i>L. acidophilus</i>		Total viable count of <i>L. acidophilus</i> (2%, T4) was 22.9 × 10 <sup>7</sup> CFU/mL for 45 days storage at 4 <sup>0</sup> C.	Shams and Wadhawan (2018)
Aloe vera drink	<i>L. acidophilus</i>		Growth of strain at 25 <sup>0</sup> C was better than stored at 4 <sup>0</sup> C during 12 days.	Bahrami et al. (2019)
Liquorice root extract	<i>L. plantarum</i>		Under different conditions, capable of thriving in liquorice extract, reaching a population of 10 <sup>8</sup> CFU/mL after 48 hours.	Mousavi and Mousavi (2019)
Pomegranate juice	<i>L. plantarum</i> ; <i>L. bulgaricus</i>		The microbiological test found no signs of yeast, mold, or coliform bacteria in the	Thakur and Sharma (2017)

			generated beverage, which had the optimal level of cultures, or $6.5 \times 10^9$ CFU/mL.	
	Whey and orange juice	<i>L. acidophilus</i> ; <i>B. bifidum</i>	The microbial count of <i>B. bifidum</i> and <i>L. acidophilus</i> were found to be $8.29 \times 10^8$ CFU/mL and $8.25 \times 10^8$ CFU/mL, respectively (24 h).	Priyanka and Anjali (2017)
	Carrot juice	<i>L. acidophilus</i> ; <i>L. planetarium</i> ; <i>L. casei</i> ; <i>B. longum</i>	Under ideal circumstances (30°C, pH 6 & 24 h), a mixture of <i>L. acidophilus</i> , <i>L. plantarum</i> , <i>L. casei</i> , and <i>B. longum</i> fermented successfully and survived in carrot juice.	Rafiq et al. (2016)
	Mango juice	<i>L. acidophilus</i> (MTCC10307); <i>L. delbrueckii</i> (MTCC911); <i>L. plantarum</i> (MTCC9511); <i>L. casei</i>	After 72 hours of fermentation at 30°C, the pH was decreased to 3.2, the acidity rose by 1.72%, and the viable cell count reached $1.0 \times 10^9$ CFU/mL.	Reddy et al. (2015)
	Fermented mixture drink (pineapple, apple and mangifera)	<i>L. casei</i> (PTCC 1608)	After 28 days, the optimal treatment, which comprises a concentration of 30% juice with a density of $10^7$ CFU/mL (containing 15% pineapple juice, 7.5% apple juice, and 7.5% mango juice), has the greatest bacteria levels.	Mashayekh et al. (2015)
	Aloe vera drink	<i>L. acidophilus</i> ; <i>L. casei</i> ; <i>L. reuteri</i> ; <i>L. fermentum</i> ; <i>L. plantarum</i>	<i>L. acidophilus</i> and <i>L. fermentum</i> are good choices for Aloe vera drinks.	Sarlak et al. (2016)
	Beetroot	<i>L. casei</i> 431	Can be stored for 6	Gamage et

	juice		weeks under refrigerated condition with $10^8$ - $10^{10}$ CFU/mL as functional drink.	al. (2016)
	Vegetable juice (beetroot, carrot and celery)	<i>L. acidophilus</i> LA-5; <i>L. casei</i> 431	Good survival of probiotic viability was obtained higher than $1 \times 10^7$ CFU/mL.	Profir et al. (2015)
	Apple juice	<i>L. plantarum</i> PCS 26	Live bacteria of $10^6$ CFU/ml concentration remain for about 30 days.	Dimitrovski et al. (2015)
	Cornelian cherry juice	<i>L. rhamnosus</i> ; <i>L. plantarum</i> ; <i>L. casei</i>	After 28 days, <i>L. casei</i> population ( $\log 8.00$ CFU/mL) had increased even higher.	Nematollahi et al. (2016)
	Moringa ( <i>Moringa oleifera</i> ) leaves juice based beetroot ( <i>Beta vulgaris</i> ) beverage	<i>L. plantarum</i> ; <i>E. hirae</i>	Fermentation reduced raffinose content by 60% and showed antibacterial activity with 30 days shelf life at $4^0$ C.	Vanajakshi et al. (2015)
	Vegetable juice mixture: Carrot ( <i>Daucus carota</i> ), bitter gourd ( <i>Momordica charantia</i> ), and bottle gourd ( <i>Lagenaria siceraria</i> )	<i>L.s acidophilus</i> (NCDC 11); <i>L. plantarum</i> (NCDC 414); <i>P. pantosaceus</i> (MT CC 2819)	<i>L. plantarum</i> strain could be used for probiotic culture to make healthy vegetable juice mixture and can survive low pH and high acidic condition at $4^0$ C and possessed $7.2 \log$ CFU/mL (4 weeks storage).	Sharma and Mishra (2013)
	Peach ( <i>Prunus persica</i> )	<i>L. plantarum</i> (DSMZ 20179); <i>L.</i>	It is feasible to choose <i>L. delbrueckii</i> as a culture to create	Pakbin et al. (2014)

	juice	<i>delbrueckii</i> (DS MZ 15996); <i>L. casei</i> (DSMZ 20011)	probiotic beverages with a cell density of $10^6$ CFU/mL.	
	Whey and pineapple juice	<i>L. acidophilus</i>	Had shelf life of 24 days ( $1.8 \times 10^7$ cfu/ml) at $5 \pm 1^{\circ}\text{C}$ and 48h ( $9.5 \times 10^8$ cfu/ml) at $30 \pm 1^{\circ}\text{C}$ with 1% <i>L. acidophilus</i> inoculum with whey (65 parts) and pineapple juice (35 parts).	Shukla and Admassu (2013)
	Cashew apple juice	<i>L. casei</i> (NRRL B-442)	Up to 21 days of storage, 20% maltodextrin powder showed survival rates of more than 70% at ambient temperature.	Pereira et al. (2014)
	Mixed tomato and watermelon juice	<i>L. fermentum</i> (MTCC1325); <i>L. casei</i> (MTCC1423)	<i>L. fermentum</i> grown at a lower temperature ( $30^{\circ}\text{C}$ ) and <i>L. casei</i> produced at a higher temperature ( $37^{\circ}\text{C}$ ) fared better after 4 weeks of cold storage at $4^{\circ}\text{C}$ .	Sivudu et al. (2014)
	Pomegranate juice	<i>L. plantarum</i> ; <i>L. delbrueckii</i> ; <i>L. paracasei</i> ; <i>L. acidophilus</i>	<i>L. plantarum</i> ( $2.8 \times 10^5 \pm 0.05 \times 10^5$ CFU/ml) and <i>L. delbrueckii</i> ( $1.5 \times 10^5 \pm 0.26 \times 10^5$ CFU/ml) showed higher viability during storage (2 weeks) at $4^{\circ}\text{C}$ .	Mousavi et al. (2011)
	Cantaloupe juice	<i>L. casei</i> (NRRL B-442)	With a 42-day refrigeration storage period and cell viability of 8.3 log CFU/ mL.	Fonteles et al. (2012)
	Cashew apple juice	<i>L. casei</i> (NRRL B-442)	More than 8.00 log CFU/mL of live cells during the 42-day storage period.	Pereira et al. (2011)
	Vegetable juice	<i>B. strain</i> (BB12)	$10^8$ CFU/mL viable cell count was	Morararu et al. (2007)

	(celery and beetroot)		achieved at 48 hours.	
	Cabbage juice	<i>L. casei</i> A4; <i>L. delbrueckii</i> D7; <i>L. plantarum</i> C3	After 48 hours of fermentation at 30°C, <i>L. plantarum</i> and <i>L. delbrueckii</i> attained $10 \times 10^8$ CFU/mL despite surviving low pH and highly acidic conditions at 4°C.	Yoon et al. (2006)
Cereal and legume based	Lupine and chickpea beverage	<i>L. plantarum</i> 299v	Highest number of microbial count observed in fermented chickpea (7.69 log CFU/mL) and germinated fermented lupine (8.16 log CFU/mL).	Criste et al. (2023)
	Oat, barley, buckwheat, and red rice beverage mixture	<i>L. plantarum</i>	It had a probiotic content of 9.70 log CFU/mL and provided shelf stability for up to two weeks when refrigerated without any quality loss.	Kokwar et al. (2022)
	Oat bran fortified raspberry dairy drink	<i>L. acidophilus</i> ; <i>L. casei</i> ; <i>B. lactis</i>	At the start of storage, oat bran considerably enhanced the vitality of the probiotic drink containing solely <i>B. lactis</i> .	Savas and Akan (2021)
	Oat-based beverage (Oat, sugar and inulin)	<i>L. plantarum</i>	Throughout storage, the <i>L. plantarum</i> population in the beverage maintained over $10^7$ CFU/g.	Wang et al. (2018)
	Sprouted wheat based beverage	<i>L. acidophilus</i> (NCDC-14)	A probiotic beverage made with wheat and <i>L. acidophilus</i> (NCDC-14) has a probiotic count of $10.43 \log_{10}$ CFU/mL.	Sharma et al. (2014)
	Oats	<i>L. plantarum</i> ATCC 8014	Reported to be stable for 21 days with a drop in CFU/ml of less than 1 log and $\beta$ -gucan	Gupta et al. (2010)

			remained unchanged during fermentation and storage.	
Soy based	Fermented soy and almond milk	<i>L. rhamnosus</i> ; <i>L.s acidophilus</i> ; <i>L. plantarum</i> ; <i>L. casei</i>	Almond and milk (AM 100) treated with <i>L. rhamnosus</i> showed highest viability of 6.686 log CFU/mL when stored at refrigerated condition (4 <sup>0</sup> C) for 21 days.	Zahrani and Shori (2023)
	Fermented soya drink	<i>Levilactobacillus brevis</i> (LOCK 0944)	<i>Chlorella vulgaris</i> and soy beverages are suitable media ingredients for <i>L. brevis</i> (LOCK 0944). The addition of algae increased the lactic acid bacteria's ability to survive in the soy drink after 30 days of storage at 4 <sup>0</sup> C.	Ścieszka et al. (2021)
	Soy-yamgurt drink	<i>L. bulgaricus</i> ; <i>S. thermophilus</i> ; <i>L. acidophilus</i>	Lactic acid bacteria had a viable cell count of 1.44 x 10 <sup>9</sup> CFU/mL in the probiotic beverage.	Rusmarilin and Andayani (2018)
	Soymilk	<i>L. acidophilus</i> ; <i>B. animalissubsp. lactis</i> Bb12; <i>S. thermophilus</i>	During cold storage for 28 days, the <i>B. animalis subsp. lactis</i> Bb12 viable cell count was higher than 10 <sup>7</sup> CFU/ml.	Božanić et al. (2011)
Other non dairy based	Fermented water soluble cashew nut extract drink	<i>L. paracasei</i>	Probiotic concentrations in fermented water-soluble cashew nut extract can exceed 7 log CFU/g.	Sousa et al. (2022)
	Instant coffee	<i>L. plantarum subsp. Plantarum</i> Dad-13	Cell viability remained over 10 <sup>7</sup> log CFU/g for all treatments and during storage.	Jannah et al. (2022)
	Saffron-based beverage	<i>L. lactis</i> ; <i>L. plantarum</i> ; <i>L. brevis</i> ; <i>L. casei</i>	Viability cell count of <i>L. casei</i> was lactis was found highest (2.5 × 10 <sup>2</sup> CFU/mL) during 3	Dabbagh Moghadda m et al. (2018)



			weeks storage (cold).	
	Artichoke juice	<i>L. plantarum</i> PCS26	The culture will retain more than $10^6$ CFU/ml after 13 days in chilled storage, according to the survivability test.	Dimitrovski et al. (2016)
	Honey beverage	<i>L. acidophilus</i>	Had shelf life of 15 days ( $94.8 \times 10^9$ CFU/mL) at $4^{\circ}\text{C}$ and 72h ( $21.4 \times 10^9$ CFU/mL) at $30^{\circ}\text{C}$ .	Nath et al. (2015)

## V. CONCLUSION

Technological breakthroughs have allowed for the controlled alteration of dietary components, allowing for the modification of numerous structural aspects of fruit and vegetable matrices. This could make them good substrates for probiotic culture because they already contain vital nutrients such as minerals, vitamins, dietary fibers, and antioxidants while avoiding dairy allergies that may prevent some segments of the population from consuming them. Presently, probiotic products are predominantly derived from milk. Nevertheless, the increasing prevalence of vegetarianism among consumers and the desire for probiotics without cholesterol have motivated scientists and researchers to explore alternative carriers for probiotics. This has led to a particular focus on vegetable and fruit juices as potential vehicles for probiotics. Minerals, vitamins, dietary fibers, and antioxidants are all found in vegetables. Unlike dairy, they do not contain allergies that can prevent certain people from ingesting them. Vegetables are thus good substrates for developing probiotic microorganisms. According to information in publications, fruits and vegetables contain a wide variety of antioxidant components, including phytochemicals. These phytochemicals, which include substances like phenolics, are thought to improve human wellbeing by reducing the risk of degenerative diseases by reducing oxidative stress and inhibiting the oxidation of macromolecular. There is a lot of interest in developing dairy-free functional beverages with probiotics. This is owing to their health benefits, as they are a healthy alternative to dairy-based probiotics. They are also low in cholesterol and popular among people who are lactose intolerant.

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