www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(6): 2956-2964

www.thepharmajournal.com
Received: 02-04-2022
Accepted: 06-05-2022

Ibahunlang Syiemlieh
Department of Food Technology & Nutrition, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Sonia Morya
Department of Food Technology & Nutrition, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Corresponding Author
Sonia Morya
Department of Food Technology & Nutrition, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Dairy and non-dairy based probiotics: A review

Ibahunlang Syiemlieh and Sonia Morya

DOI: https://doi.org/10.22271/tpi.2022.v11.i6Sak.13568

Abstract
Background: Functional foods such as probiotics have been known for their benefits to the human body owing to their potential links to health. Probiotics can be developed from various sources of bovine milk i.e. dairy based as well as from various non-dairy based sources such as fruits, vegetables, cereals and legumes. The purpose of the present review was therefore to gather information between the two sources of probiotics *viz.* dairy based and non- dairy based probiotics.
Objectives: The comparative review comprised of the comparison of both the sources along with health benefits, limitations and regulations of probiotics, safety concerns and their future prospects.
Materials and Methods: Most dairy and non-dairy based probiotics serve as a good source for the growth of beneficial microorganisms. Both categories of probiotics require certain strains which exert various health benefits like maintaining blood pressure, improving irritable bowel disease (IBD), oral health, urogenital health, and liver health and as antidepressant. However, for exerting such health benefits, the stability, viability and effectiveness of the probiotic is crucial as it depends upon the interaction of the live microorganisms and the food matrix.
Results: The safety and regulatory claims of probiotics post a major concern in accordance to the perception of consumers to the products.
Research Limitations: Probiotics need specific time, temperature, and pH for the growth and storage. Their cell viability is important and must maintain.
Conclusion: The present paper gather information from various review papers for both the sources of probiotics.

Keywords: Food matrix, health benefits, action mechanism of probiotics, probiotics, prebiotics, safety concerns

1. Introduction
Consumers all across the world have become much more aware of the relationship between nutrition and health which prompted scientific research into the discovery of foods and food components with numerous health benefits. Culminating in the development of functional foods that are foods or food ingredients have a positive influence on consumer health and minimize the risk of chronic diseases (Khan *et al.*, 2021; Salmerón, 2017) [37, 64]. Functional food research has transitioned toward the development of dietary supplementation and with the emergence of probiotics that could affect intestinal microbiota composition and function (Begum *et al.*, 2017) [11]. Probiotic foods are consist of a single or mixed culture of microorganisms that improve the consumer's gut microbial balance and hence benefit their health. In order to give beneficial effects to human body (Khan *et al.*, 2021) [37] the live microorganism need to be present more than 10^8 to 10^9 cfu/ml in probiotic products. Probiotic must be capable of withstanding the adverse conditions in the gastrointestinal tract of the body (Shori 2016).
The majority of microorganisms that are used for developing probiotic products includes Lactic Acid Bacteria (LAB) and *Bifidobacteria*, *Leuconostoc* species. The strains *of Lactobacillus bulgaricus*, *Lactobacillus fermentum*, *Lactobacillus acidophilus*, *Lactobacillus amylovarus*, *Lactobacillus crispatus*, *Lactobacillus delbrueckii*, *Lactobacillus salivarius*, *Lactobacillus fermentum*, *Lactobacillus sonii*, *Lactobacillus rhamnosus*, *Lactobacillus helveticus*, *Lactobacillus casei*, *Lactobacillus plantarum* and from *Bifidobacteria* includes *Bifidobacterium animalis*, *Bifidobacterium infantis* and *Bifidobacterium bifidum* (Turkmen *et al.*, 2019) [77].
The human intestine greatly favors the growth of these microorganisms in which they have the tendency to restrict the growth of pathogenic bacteria and can be used as a single strain or

combination of strains for its beneficial properties (Khaneghah *et al.*, 2020) [38]. It include prevention of infection in the intestinal tract, reducing the levels of serum cholesterol, boosting the immune system, improving the metabolism of lactose, helps in protein digestibility, helps in synthesizing vitamins and minerals such as it helps in calcium absorption, synthesis (Chaturvedi *et al.*, 2021) [15].

Probiotics can be developed from various sources of bovine milk i.e. dairy based and it can also be derived from various non-dairy based sources namely fruits, vegetables, cereals, legumes and in this review paper the comparison of both the sources along with health benefits, drawbacks, regulations, safety concerns and future prospects are being discussed.

2. Action Mechanism of Probiotics

The mode of action of mechanism of probiotics firstly involves the survival of the bacteria in low pH and bile salts in order to exert beneficial effects (Valero-cases *et al.*, 2020) [80]. The bacteria then needs to have the ability to colonize the intestine and produce bateriocins (microsins), short chain fatty acids and reduction of pH for their optimum growth by producing organic acids. It includes lactic acids, acetic acid, propionic acid and butyric acid (Docarmo *et al.*, 2018). Secondly, the mechanism involves the improvement of the intestinal barrier and tight junctions between the epithelial cells in which the probiotic bacteria produce peptides and mucus cells such as definsins thereby having antimicrobial effect against pathogenic bacteria by having the ability to solubilize the cell membrane (lipholicity) (Sánchez *et al.*, 2017), blocking the adhesion of pathogenic bacteria to the epithelial cells (Kumar *et al.*, 2015) [42]. Thirdly, the mechanism involves the modulation of the immune system whereby, the immune cells that are mostly located in the small bowel, make up the gut associated lymphoid tissue (GALT). The activation of immune response through immune receptors such as Toll like receptors (TLRs) produce T-cells and cytokines. This leads to the activation of B cells that produces antibodies particularly IgA that inhibits pathogenic bacteria (Fig 1) (Bute, 2014) [14].

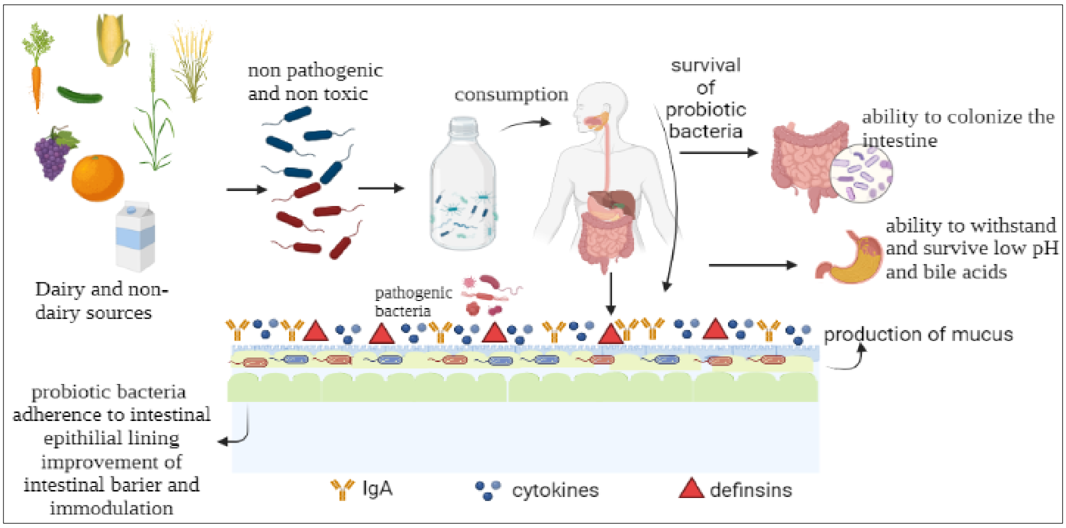

Fig 1: Mechanism of action of probiotics

3. Dairy based probiotic products

Dairy products commonly fermented with LAB i.e. lactic acid bacteria have been extensively used as probiotics in the market and has been popular and expanding progressively in the dairy industry. The various types of dairy based probiotic products and microorganisms involved in the production are discussed in (Table 1).

Table 1: Probiotic strains and their dairy based probiotic products

Dairy-based probiotics	Organisms used	References
Koumiss	*Lactobacilli*, Non-lactose- fermenting yeasts	Turkmen *et al.*, 2019 [77]
Kefir	*Lactobacillus kefir*	Kandylis *et al.*, 2016 [36]
Yogurt	*Lactobacillus bulgaricus, Streptococcus thermophilus*	Sarkar, 2018 [68]
Butter milk	*Lactococcus lactis, Lactobacillus bulgaricus*	Ranadheera *et al.*, 2017 [61]
Bifidus milk	*Bifidobacterium bifidum, Bifidobacterium longum*	Khorshidian *et al.*, 2020 [39]
Acido- bifidus milk	*Lactobacillus acidophilus, Bifidobacterium* sp.	Hati *et al.*, 2017 [33]
Whey and sorghum beverage	*Lactobscillus acidophilus Lactobacillus casei, Lactobacillus rahmnosus*	Morya *et al.*, 2017a, Morya *et al.*, 2017b [50-51]
Whey beverage	*Bifidobacterium lactis, Lactobacillus acidophilus*	Shori, 2015 [70]
Fermented skim milk	*Lactobacillus acidophilus Bifidobacterium animalis* subsp. *Lactis*	Ranadheera *et al.*, 2017 [61]
Cheddar cheese	*Lactobacillus lactis* subsp. *lactis, Lactobacillus helvetics, Streptococcus thermophiles, Lactobacillus rhamnosus*	Ulpathakumbura *et al.*, 2016 [78]
Minas cheese	*Lactobacillus paracasei, Lactococcus* subsp. *Streptococcus thermophilus*	Sperry *et al.*, 2018 [72]

4. Drawbacks of dairy based probiotics

Probiotics has been consumed traditionally through dairy foods that are being fermented such as yoghurt, koumiss, kefir, sour milk, bifidus milk, acidophilus milk which are mostly from the origin of bovine. The dairy based products contain lactose which is a sugar component present in animal based milk. The lactose sugar component in milk needs to be broken down by lactase enzymes which lacking in lactose intolerant people. This emergence of indigestion of bovine's milk, increase trends of veganism, vegetarianism, and ethical concerns of animal welfare confers as the drawbacks of the dairy products and beverages derived from dairy sources (Abu-Ghannam *et al.*, 2015) [2].

4.1 Lactose Intolerance
The dairy probiotic products are obtained from bovine milk that contains lactose which is a sugar component present in animal based milk. Lactase enzymes namely beta-galactosidase are required to break down this sugar component in milk and the absence of which results in inability to hydrolyze or break down lactose into monosaccharaides units namely galactose and glucose. When indigested or non-hydrolyzed lactose reaches the large intestines, it is degraded by bacterial enzymes resulting in osmotic diarrhea, gastrointestinal pain and flatulence to those who consume milk and milk products that are lactose intolerant (Khan *et al*., 2021; Kumar *et al*., 2015) [42, 37].

4.2 Milk Protein allergens
Cow's milk protein allergy (CMPA) is the common food allergen in children and is defined as a reproducible allergic response to one or more cow's milk proteins (CMP) which are usually caseins or whey beta-lacto globulin. They are being facilitated by one or more immune mechanisms in which the allergen's prevalence is estimated to be around 5% during the first year of life (Qamer *et al*., 2019) [60]. The protein allergy can be mediated by immunoglobulin E (IgE) or non- IgE-mediated. IgE-mediated reactions typically occur relatively soon after ingestion whereas non-IgE-mediated reactions can take up to 48 hours to manifest. Reactions mediated to skin, cardiac, gastrointestinal and respiratory signs and symptoms can range in severity and can include life-threatening anaphylaxis whereas, non-IgE-mediated reactions can include allergic food protein induced proctocolitis and enteropathy (Walsh *et al.*, 2016) []82.

4.3 Cholesterol content
The amount of fat in milk varies depending on its source and cow milk has a fat content of about 4-5 % whereas buffalo milk has a fat content of about 7-8 %. High levels of milk consumption are expected to raise the adequate amount of low density lipoproteins (LDLP). LDLP is a bad cholesterol present in the blood that have shown to be a significant risk factor for heart or cardiovascular and obesity. This health hazard can be reduced by lowering the consumption LDLP cholesterol and saturated fat (Natt and Katyal, 2021) [53].

5. Non-dairy probiotic product
5.1 Need of focusing on nondairy products
Milk and other dairy products provide health advantages of probiotics, however, cholesterol levels, lactose intolerance, and allergic milk proteins are limiting factors in dairy probiotic products (Rasika *et al*. 2021) [62]. Lactose intolerance affects around 75% of the world's population which is caused by a lack of the lactase enzyme that is required to hydrolyzes lactose into sugars that may be absorbed by the body (namely glucose and lactose) in order to provide energy. Besides this with an increase in eating habits like vegetarianism in both developed and developing countries there is also a high demand for plant based probiotic products. High cholesterol levels in dairy products also poses severe health problems as it increase the risk of having cardiovascular disease. Furthermore, non-dairy probiotic beverages are also cheaper alternative to dairy products for the delivery of probiotics in developing countries. Therefore, there is a need in the development and research for replacement of dairy probiotic products that are rich in nutrients and also provides health promoting properties (Kumar *et al.*, 2015) [42].

5.2 Types of Non- dairy probiotic products
The various types of non -dairy probiotic beverage can be obtained from juices of fruits, vegetables, milk from cereals, legumes and pulses or they can be obtained by combinations. Table 2 discusses the various types of non- dairy probiotic products, and microorganisms involved in the production.

Table 2: Probiotic strain and Non-dairy probiotic products

Probiotics	Probiotic microorganisms	References
	Cereal and legume based	
Oat flour, milk	*Lactobacillus plantarum Bifidobacterium lactis*	Ravindran and RadhaiSri, 2020 [63]; Asadzadeh *et al*. 2021 [8]
Wheat, millet, maize milk or flour	*Lactobacillus plantarum, Lactobacillus acidophilus, Lactobacillus fermentum,, Lactobacillus coprophilus,, Leuconostoc reffinolactis, Leuconostoc mesenteroides, Lactobacillus brevis, Saccharomyces cerevisiae, Candida tropicalis, Candida glabrata, Geotrichum penicillatum, Geotrichum candidum*	Tesfaye *et al*., 2019 [75]
Sorghum, ragi flour	*Leuconostoc, Enterococcus and Lactobacillus brevis*	Salmeron *et al*., 2015
Wheat flour, malt	*Lactococcus lactis*	Rasika *et al*., 2021 [62]
Soymilk	*Bifidobacterium animalis, Lactobacillus acidophilus, Kluyveromyces marxianus, Kluyveromyces lactis, Lactobacillus brevis, Lactobacillus kefir.*	Sridharan and Das, 2019 [73]; Kumari *et al*., 2018 [43]
Buckwheat and oat	*Lactobacillus acidophilus*	Vasile *et al*., 2016 [79]
Gowé	*Lactobacillus fermentum, Lactobacillus mucosae, Pediococcus acidilactici*, and *Weissella confusa,*	Enujiugha and Badejo, 2017 [21]
Peanut-soy milk	*Pediococcus acidilactici, Lactobacillus lactis, Lactobacillus rhamnosus, Lactobacillus acidophilus.*	do Amaral Santos *et al*., 2014 [18]
Chickpeas milk	*Lactobacillus plantarum*	Paredes-Toledo, 2021 [56]
Quinoa milk	*Lactobacillus plantarum Bifidobacterium longum*	Ayub *et al*., 2021
Buckwheat, dark buckwheat milk	*Lactobacillus rhamnosus, Lactobacillus plantarum*	Kockova and Valík, 2014 [40]; Matejcekova *et al*., 2017
Ogi	*Saccharomyces Cerevisiae and Bacillus* sp.	Kohajdova, 2017
Buckwheat	*Lactobacillus plantarum*	Ilango and Antony, 2021 [35]

Fruit Juice Based Probiotics		
Apple juice	*Lactobacillus paracasei Lactobacillus plantarum Lactobacillus rhamnosus*	Lilio-Perez *et al*., 2021; Aspri *et al*., 2020 [9]
Pine apple juice	*Lactobacillus rhamnosus, Lactobacillus casei, Lactobacillus paracasei*	Adebayo Tayo *et al*., 2016 [3]
Mango juice	*Lactobacillus casei*	Lilio-Perez *et al*., 2021
Raspberry juice	*Lactobacillus casei*	Olivares *et al*., 2019 [54]
Orange juice	*Lactobacillus acidophilus, Bifidobacterium bifidum*	Alves *et al*., 2017 [6]
Amla juice	*Lactobacillus paracasei*	Peerajan *et al*., 2016 [57]
Peach Juice	*Lactobacillus casei, Lactobacillus delbrueckii*	Pakbin *et al*., 2014 [55]
Sweet lemon juice	*Lactobacillus plantarum*	Hashemi *et al*., 2017 [32]
Sugarcane juice	*Lactobacillus casei*	Amanda *et al*., 2018 [17]
Watermelon juice	*Lactobacillus plantarum*	Santos *et al*., 2019 [67]
Mosambi juice	*Saccharomyces cerevisiae, Wickerhamomyces anomalus, Pichia barkeri, Yarrowia lipolytica*	Suvarna *et al*., 2018 [74]
Vegetable based probiotics		
Pumpkin	*Lactobacillus* casei	Genevois *et al*., 2019 [27]
Artichoke	*Lactobacillus casei*	Garbetta *et al*., 2018 [26]
Cabbage juice	*Lactobacillus casei*	Dimitrovski *et al*., 2016 [17]
Broccolli	*Lactobacillus bulgaricus, Streptococcus thermophilus, Lactobacillus acidophilus, Bifidobacterium bifidum*	Maryati *et al*., 2017 [46]
Turnip	*Lactobacillus fermentum, Lactobacillus Paracasei, Lactobacillus plantarum*	Ghaempanah *et al*., 2020 [28]

5.3 Limitations of non- dairy probiotic products

The viability of the beneficial bacteria during processing and storage of fruit, vegetables and cereal foods is dependent on water activity, pH, and the type of strain. Fruit and vegetable juices also include some necessary nutrients but, variables such as low pH (which is due to the production of large quantities of organic acids and dissolved oxygen), may impair probiotic survival. Furthermore, because dairy products are often stored at temperatures close to 5 °C, probiotic cell viability is likely to be maintained throughout the product's shelf life. However, the storage of non-dairy products are mainly at room temperature which can provide a significant obstacle to probiotic survival (Abu-Ghanna and Rajauria, 2015) [2].

6. Health benefits of probiotic products

Probiotics play an important role to reduce the health related issue. There are many evidence where probiotics shown to resolve the problems of different health issues such as blood pressure, inflammatory bowel disease, antidepressant, oral health, and non-alcoholic fatty liver disease (Fig 2).

6.1 Probiotics role in blood pressure

The studies shows that simulation of cholesterol occurs by the probiotic cell attachment to the cholesterol, and thereby effective removal of cholesterol takes place by probiotics (Khan *et al*., 2021) [37]. They can improve the blood pressure by lowering down LDLP, reducing the glucose level in blood or serum cholesterol whenever the levels are increased and by regulating renin- angiotensin system. The probiotic strains that contribute to improving the blood pressure includes *Saccharomyces cerevisiae*, *Bifidobacterium brevis Lactobacillus bulgaricus*, *Streptococcus thermophiles*, *Bifidobacterium longum* and *Lactobacillus kefir* (Abatenh *et al*., 2018) [1].

6.2 Probiotics role in Inflammatory Bowel Disease or IBD

Inflammatory Bowel Disease (IBD), which involves Crohn's disease and ulcerative colitis are gaining attention due to their high prevalence (Morya *et al*., 2021) [52]. These are chronic diseases which cannot be cured but can be controlled or prevented by consuming probiotics. Probiotics include helpful bacteria for maintaining a healthy gut by altering the mucosal immune system through a process that is being mediated by Toll- like receptors. It promotes T-helper 1 cell differentiation, increase phagocytic and natural killer cell activity. It inhibit the nuclear factor kappa-light-chain-enhancer of activated B cells pathway which augmented antibody production and anti- inflammatory cytokines like interleukin. The transforming growth factor beta up regulated, results in reduction in gut inflammation (Glassner *et al*., 2020) [29]. The microorganisms that contribute to the treatment of IBD include *Bifidobacterium longum*, *Saccharomyces boulardii*, *Lactobacillus rhamnosus*, *Lactobacillus plantarum*, *Lactobacillus bulgaricus*, *Lactobacillus casei*, *Bifidobacterium breve*, *Bifidobacterium infantis* and *Streptococcus thermophiles* (Guandalini and Sansotta, 2020) [30].

6.3 Probiotics as antidepressants

Gut probiotic bacteria are beneficial in the bidirectional connection between the brain and the gut, whereby, it helps in creating, regulating and increasing the production of glutamate, dopamine, serotonin, histamine, acetylcholine, norepinephrine. These are monoamines that are essential for reducing depression. Probiotic bacteria also help in generating butyrate which is a short chain fatty acid that enhances 5-hydroxytryptamine receptors which are essential for increasing the production levels of serotonin (Young *et al*., 2020). Clostridia metabolites such as 4-cresol and 4-hydroxyphenylacetate (4-HPA) on the other hand, block dopamine-hydroxylase, which is an enzyme essential for conversion of monoamines such as dopamine and norepinephrine (Lund *et al.* 2018) [45]. The gut microorganisms that contribute as antidepressants include *Lactobacillus reuteri*, *Lactobacillus plantarum*, *Lactobacillus gasseri*, *Lactobacillus kefiranofaciens*, *Lactobacillus bevis*, *Bifidobacterium longum*, *Bifidobacterium breve*, and *Bifidobacterium infantis* (Young *et al*., 2020).

6.4 Probiotics role in oral health

Periodontal disease or gum disease and dental caries or tooth decay are two of the most common and serious oral condition. The treatment of these diseases or their complications requires systemic use of antimicrobial drugs which can cause gastrointestinal side effects due to antibiotics broad spectrum, bacterial resistance, and allergic reactions (Semonario-Amez *et al*., 2017) [69]. Oral microbiota deposition can be readily disrupted and the presence of pathogenic organisms can result in a variety of oral health issues, including dental caries, periodontitis, and halitosis (Allaker *et al.*, 2017) [5]. However, with the use of probiotic, managing the oral microflora appears to be an effective method to control oral conditions. The organisms include species of *Lactobacillus brevis*, *Lactobacillus reuteri*, *Lactobacillus rhamnosus*, *Bifidobacterium animalis*, *Streptococcus salivarius*, *Streptococcus oralis*, *Streptococcus uberis*, *Streptococcus dentisani*, *Streptococcus mutans*, *Bacillus subtilis* and *Bacillus licheniformis.* (Tester and Al-Ghazzewi, 2018) [76].

6.5 Probiotics role in Non-alcoholic Fatty Liver Disease (NAFLD)

Modifications in the type and amount of microorganisms that live in the intestinal lumen pose an important role in hepatocyte function. The changes in the type and the population of the microorganisms that live in the intestinal tract can cause serious and harmful liver dysfunctions like nonalcoholic fatty liver disease (NAFLD). It encompasses a wide range of hepatic pathologies from simple steatosis to nonalcoholic steatohepatitis (NASH) which thereby, lead to liver cirrhosis and hepatocellular (HCC) (Meroni *et al.*, 2019) [48]. Insulin resistance (IR), physical inactivity, obesity, genetic and environmental factors contribute to the development of hepatic steatosis and liver damage in NAFLD patients (Famouri *et al.*, 2017) [22]. This is caused due to alteration in intestinal permeability that creates a favourable condition for over-growrh of microorganisms, mucosal inflammation and translocation of both invasive pathogens and harmful by-products. This affects the hepatic fat composition and exacerbates pro-inflammatory and fibrotic processes (Gao *et al.*, 2016) [25]. The gut microbiota contributes to inhibit NAFLD by anatomo-functional interaction between the gut and the liver in which they block the entry of microorganisms to blood flow and to the liver by increasing the strength of intestinal barrier (Ferolla *et al.*, 2015) [23].

The microorganisms that contribute to treatment of liver disease includes *Lactobacillus acidophilus*, *Lactobacillus johnsonii*, *Lactobacillus paracasei*, *Lactobacillus reuteri*, *Lactobacillus rhamnosus*, *Lactobacillus brevis*, *Lactococcus lactis*, *Bifidobacterium adolescentis*, *Bifidobacterium longum*, *Bifidobacterium lactis* (Meroni *et al.*, 2019) [48].

6.6 Probiotics role in Urogenital and vaginal health

A variety of *Lactobacillus* species dominate the microflora in a healthy human vagina and they serve an important role in preventing women from genital infections (Borges *et al.*, 2014) [12]. The deficiency in *Lactobacilus species* can disrupt the microbial balance in the vagina that results in the growth and dominance of anaerobic bacteria such as *Gardnerella vaginalis*, *Bacteroides*, *Prevotella* and *Mobiluncus species.* This microbial imbalance leads to a condition termed as bactrial vaginosis (BV) (Petricevic *et al.*, 2014) [59]. Microbial imbalance also leads to infections like Urinary Tract infection (UTI) caused by *Escherichia coli* (Hanson *et al.*, 2016) [31] and vagina yeast infection mainly by the colonization or dominance of yeast growth *viz*. *Candida albicans* (Pendharkar *et al.*, 2015) [58]. These infections are mostly recurrent and the treatment of such involve consumption of antibiotics which can cause diarrhoea, depression, kidney related problems and antimicrobial resistance (Petricevic *et al.*, 2014) [59].

However, consumption of probiotics could improve vaginal health, whereby, *lactobacilli* can prevent the adherence and colonization of pathogenic bacteria by their ability to bind to uroepithelial cells, production of bio- surfactants and mucosa (Akgül and Karakan, 2018) [4]. Furthermore, the production of acid such as lactic, acetic acid and antimicrobial substances such as bacteriocins and hydrogen peroxide leads to the reduction in pH of 4.5 or less that hampers the growth of pathogenic bacteria and maintains urogenital and vaginal health (Buggio *et al.*, 2019) [13]. The strains clinically shown to have an effect for improving vagina health include *Lactobacillus rhamnosus*, *Lactobacillus reuteri* and *Lactobacillus fermentum* (Daliri *et al.*, 2015) [16].

7. Regulations for probiotic products

Efficacy, safety and regulation of health claims should be considered for probiotic products. The Food and Drug Administration classify products based on the way it has been marketed by the manufacturer. For example if a probiotic product make a health claim which indicate treatment, therapy, prevention, diagnosis of disease it is then labelled as food supplements or dietary supplements. However, if the probiotic product has clinical trials for its formulation, it can be classified as a medical food intended for human consumption or as pharmaceutical (Hoffmann *et al.*, 2014) [34]. In the present age, probiotics are found and regulated in three categories *viz*. Category 1 that include fermented foods having generally regarded as safe (GRAS) status for *Bifidbacterium*, *Lactococcus and Lactobacillus species.* Category 2 that include dietary supplements. Category 3 that include pharmaceutical. However, the categorization depends upon the manufacturers and the demands from regulatory authorities (Zuntar *et al.*, 2020).

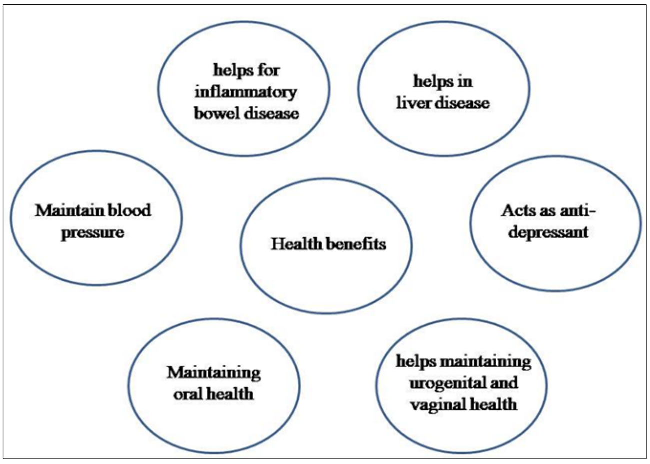

Fig 2: Health benefits of probiotics.

8. Safety of Probiotics

Food safety, including the inclusion of probiotics in meals intended for human consumption, is a critical aspect in preventing or avoiding health risks or issues. Some clinical research, case reports, and randomized controlled trials have indicated that probiotics are not fully safe for patients and consumers, with daily use of probiotics causing issues in various populations such as systemic infections, immunological activation, and gene transfer (Kumar *et al.*, 2015) [42]. The populations which are at higher risk of getting side effects include patients that have complexity in their immune response, critically ill patients, post-surgery patients, elderly populations and critically sick infants (Sanders *et al.*, 2018; Doron and Snydman. 2015) [20, 66].

9. Future prospects

By using various food matrices as a vehicle for probiotic microorganisms is a challenging task. As mentioned in this article, various foods are being used as a vehicle for delivering probiotic products and thereby, each food matrices has unique properties, advantages and drawbacks which may also impose technological barriers for successful delivery of probiotics. Development of novel, economical, and technologically feasible dairy and non- dairy products that satisfy consumer demands and also keeping into consideration of the products safety concerns should be the focus of future research efforts (Ranadheera *et al.*, 2017; Shori, 2015; Kumar *et al.*, 2015; Freedman *et al.*, 2020) [70, 42, 61]. The future prospects of probiotics can include: product development of probiotics that satisfy the demands of the consumers, novel development of probiotic products that targeted specific market consumers such as for infants, children, elderly, chronically ill patients, stability and viability of microorganisms strains in various food matrices, incorporation of probiotics into foods that are not fermented, novel technology techniques for improving the stability and viability of probiotics, development of probiotic products as gummies, RTE (Ready To Drink), beverages, snacks, jams, marmalades, research on the impact of combining multiple strains of probiotics. Hence, there is a huge scope on the future research and development regarding probiotics (Sanders *et al.* 2018; Zuntar *et al.* 2020) [66].

10. Conclusion

The production and development of probiotics is seen to be evolving throughout the years with many innovations and novel ideas that have been introduced involving probiotics in relation to its relationship with human health. The use of probiotics are mainly popular in dairy-based, which also contributes to some drawbacks *viz*. lactose intolerance, cholesterol and vegan lifestyle. Non-dairy based probiotics on the other hand, serves as a good alternative to dairy based probiotics. However, they pose a challenge regarding the survival of the organisms. Therefore, there is need of more scientific investigation in terms of understanding the stability and viability of the microorganisms with various food matrices and their safety concerns which is also plays a very important role in food safety of the consumer.

11. Acknowledgement

The authors would like to thank Lovely Professional University, Punjab, India.

12. References

1. Abatenh E, Gizaw B, Tsegay Z, Tefera G, Aynalem E. Health benefits of probiotics. Journal of Bacteriological Infectious Disease. 2018;2:1.
2. Abu-Ghanna N, Rajauria G. Non-dairy probiotic products. Advances in Probiotic Technology, 2015, 364-383.
3. Adebayo Tayo B, Akpeji S. Probiotic viability, physicochemical and sensory properties of probiotic pineapple juice. Fermentation. 2016;2(4):20.
4. Akgül T, Karakan T. The role of probiotics in women with recurrent urinary tract infections. Turkish Journal of Urology. 2018;44(5):377.
5. Allaker RP, Stephen AS. Use of probiotics and oral health. Current Oral Health Reports. 2017;4(4):309-318.
6. Alves NN, de Oliveira Sancho S, da Silva ARA, Desobry S, da Costa JMC, Rodrigues S. Spouted bed as an efficient processing for probiotic orange juice drying. Food Research International. 2017;101:54-60.
7. Amanda E, Choo WS. Effect of refrigerated storage on the physicochemical characteristics and viability of *Lactobacillus plantarum* in fermented watermelon juice with or without supplementation with inulin or fructooligosaccharide. Journal of Food Processing and Preservation. 2018;42(12):e13831.
8. Asadzadeh A, Jalali H, Azizi MH, Mohammadi Nafchi, A. Production of oat bran functional probiotic beverage using *Bifidobacterium lactis*. Journal of Food Measurement and Characterization. 2021;15(2):1301-1309.
9. Aspri M, Papademas P, Tsaltas D. Review on non-dairy probiotics and their use in non-dairy based products. Fermentatio. 2020;6(1):30.
10. Ayub M, Castro-Alba V, Lazarte CE. Development of an instant-mix probiotic beverage based on fermented quinoa with reduced phytate content. Journal of Functional Foods. 2021;87:104831.
11. Begum PS, Madhavi G, Rajagopal S, Viswanath B, Razak MA, Venkataratnamma V. Probiotics as functional foods: potential effects on human health and its impact on neurological diseases. International Journal of Nutrition, Pharmacology, Neurological Diseases. 2017;7(2):23.
12. Borges S, Silva J, Teixeira P. The role of lactobacilli and probiotics in maintaining vaginal health. Archives of Gynecology and Obstetrics. 2014;289(3):479-489.
13. Buggio L, Somigliana E, Borghi A, Vercellini P. Probiotics and vaginal microecology: fact or fancy?. Bio Med Central Women's Health. 2019;19(1):1-6.
14. Butel MJ. Probiotics, gut microbiota and health. Médecine et Maladies Infectieuses. 2014;4(1):1-8.
15. Chaturvedi S, Khartad A, Chakraborty S. The potential of non-dairy synbiotic instant beverage powder: Review on a new generation of healthy ready-to-reconstitute drinks. Food Bioscience. 2021;42:101195.
16. Daliri EBM, Lee BH. New perspectives on probiotics in health and disease. Food Science and Human Wellness, 2015;4(2):56-65.
17. Dimitrovski D, Stojanovska MC, Simonovska J, Doneva Sapceska D. Lactic acid fermentation of cabbage juice by probiotic strain. In III International Congress Food Technology, Quality and Safety, 2016, 67-73.
18. Do Amaral Santos CCA, da Silva Libeck B, Schwan RF. Co-culture fermentation of peanut-soy milk for the development of a novel functional beverage. International Journal of Food Microbiology. 2014;186:32-41.
19. Do Carmo MS, Itapary dos Santos C, Araujo MC, Girón JA, Fernandes ES, Monteiro-Neto V. Probiotics, mechanisms of action, and clinical perspectives for diarrhea management in children. Food & Function, 2018;9(10):5074-5095.
20. Doron S, Snydman DR. Risk and safety of probiotics. Clinical Infectious Diseases. 2015(60):S129-S134.
21. Enujiugha VN, Badejo AA. Probiotic potentials of cereal-based beverages. Critical Reviews in Food Science and Nutrition. 2017;57(4):790-804.
22. Famouri F, Shariat Z, Hashemipour M, Keikha M, Kelishadi R. Effects of probiotics on nonalcoholic fatty liver disease in obese children and adolescents. Journal of Pediatric Gastroenterology and Nutrition.

2017;64(3):413-417.
23. Ferolla SM, de Almeida Armiliato GN, Couto CA, Ferrari TCA. Probiotics as a complementary therapeutic approach in nonalcoholic fatty liver disease. World Journal of Hepatology. 2015;7(3):559.
24. Freedman SB, Schnadower D, Tarr PI. The probiotic conundrum: regulatory confusion, conflicting studies, and safety concerns. Jama. 2020;323(9):823-824.
25. Gao X, Zhu Y, Wen Y, Liu G, Wan C. Efficacy of probiotics in non-alcoholic fatty liver disease in adult and children: A meta-analysis of randomized controlled trials. Hepatology Research. 2016;46(12):1226-1233.
26. Garbetta A, D'Antuono I, Sisto A, Minervini F, Cardinali A, Lavermicocca P. Effect of artichoke fermentation by probiotic strain *Lactobacillus paracasei* LMG P-22043 and of digestion process on polyphenols and antioxidant activity. Journal of Functional Foods. 2018;45:523-529.
27. Genevois C, Pieniazek F, Messina V, Flores S, de Escalada Pla M. Bioconversion of pumpkin by-products in novel supplements supporting *Lactobacillus casei*. Lebensmittel-Wissenschaff and Technologie. 2019;105:23-29.
28. Ghaempanah M, Hashemiravan M, Sharifan A. Production of Probiotic Fermented Beverage from Turnip (Brassica rapa) and Purple Carrots (*Daucus carota*) Using *Lactobacillus plantarum*, *Lactobacillus fermentum* and *Lactobacillus paracasei* and *Saccharomyces cerevisiae*. Journal of Food Technology and Nutrition. 2020;17(66):31-40.
29. Glassner KL, Abraham BP, Quigley EM. The microbiome and inflammatory bowel disease. Journal of Allergy and Clinical Immunology. 2020;145(1):16-27.
30. Guandalini S, Sansotta N. Probiotics in the treatment of inflammatory bowel disease. Probiotics and Child Gastrointestinal Health. 2019;10:101-107.
31. Hanson L, Vande Vusse L, Jerme M, Abad CL, Safdar N. Probiotics for treatment and prevention of urogenital infections in women: A systematic review. Journal of Midwifery and Women's Health. 2016;61(3):339-355.
32. Hashemi SMB, Khaneghah AM, Barba FJ, Nemati Z, Shokofti SS, Alizadeh F. Fermented sweet lemon juice (Citrus limetta) using *Lactobacillus plantarum* LS5: Chemical composition, antioxidant and antibacterial activities. Journal of Functional Foods. 2017;38:409-414.
33. Hati S, Mandal S, Prajapati JB. An in-depth look at types of functional fermented milk-based beverages. Dairy products. 2013. Available online: http://www.fnbnews.com/Dairy-Products/An-in-depth-look-at-types-of-functional-fermented-milk-based-beverages (Accessed on 12 May 2022).
34. Hoffmann DE, Fraser CM, Palumbo F, Ravel J, Rowthorn V, Schwartz J. Probiotics: achieving a better regulatory fit. Food and Drug Law Journal. 2014;692:237.
35. Ilango S, Antony U. Probiotic microorganisms from non-dairy traditional fermented foods. Trends in Food Science & Technology. 2021;118:617-638.
36. Kandylis P, Pissaridi K, Bekatorou A, Kanellaki M, Koutinas AA. Dairy and non-dairy probiotic beverages. Current Opinion in Food Science. 2016;7:58-63.
37. Khan FM, Morya S, Chattu VK. Probiotics as a boon in food diligence emphasizing the therapeutical role of probiotic beverages on consumers health. Journal of Applied and Natural Science. 2021;13(2):700-714.
38. Khaneghah AM, Abhari K, Eş I, Soares MB, Oliveira RB, Hosseini H. Interactions between probiotics and pathogenic microorganisms in hosts and foods: A review. Trends in Food Science & Technology. 2020;95:205-218.
39. Khorshidian N, Yousefi M, Mortazavian AM. Fermented milk: The most popular probiotic food carrier. In Advances in Food and Nutrition Research. 2020;94:91-114.
40. Kockova M, Valík Ľ. Development of new cereal-, pseudocereal-, and cereal-leguminous-based probiotic foods. Czech Journal of Food Sciences. 2014;32(4):391-397.
41. Kohajdová Z. Fermented cereal products. In Current Developments in Biotechnology and Bioengineering, 2017, 91-117.
42. Kumar H, Salminen S, Verhagen H, Rowland I, Heimbach J, Bañares S. Novel probiotics and prebiotics: road to the market. Current Opinion in Biotechnology. 2015;32:99-103.
43. Kumari A, Angmo K, Monika S, Bhalla TC. Functional and technological application of probiotic *L. casei* PLA5 in fermented soymilk. International Food Research Journal. 2018;25(5):2164-2172.
44. Lillo-Pérez S, Guerra-Valle M, Orellana-Palma P, Petzold G. Probiotics in fruit and vegetable matrices: Opportunities for nondairy consumers. Lebensmittel-Wissenschaff and Technologie. 2021;151:112106.
45. Lund ML, Egerod KL, Engelstoft MS, Dmytriyeva O, Theodorsson E, Patel BA. Enterochromaffin 5-HT cells–A major target for GLP-1 and gut microbial metabolites. Molecular Metabolism. 2018;11:70-83.
46. Maryati Y, Susilowati A, Melanie H, Lotulung PD. Characteristic of phenolic compound and antioxidant activity of fermented broccoli (*Brassica oleracea* L. ssp.) beverage by lactic acid bacteria (LAB). In AIP Conference Proceedings. AIP Publishing LLC. 2017;1803(1):020025
47. Matejčeková Z, Liptáková D, Valík Ľ. Functional probiotic products based on fermented buckwheat with *Lactobacillus rhamnosus*. Lebensmittel-Wissenschaff and Technologie-Food Science and Technology. 2017;81:35-41.
48. Meroni M, Longo M, Dongiovanni P. The role of probiotics in nonalcoholic fatty liver disease: A new insight into therapeutic strategies. Nutrients. 2019;11(11):2642.
49. Min M, Bunt CR, Mason SL, Hussain MA. Non-dairy probiotic food products: An emerging group of functional foods. Critical Reviews in Food Science and Nutrition. 2019;59(16):2626-2641.
50. Morya S, Chandra R, Seelam BS. Microbial characteristics of whey and sorghum based low fat probiotic beverage. International Journal of Chemical Studies. 2017a;5(4):403-406.
51. Morya S, Chandra R, Thompkinson DK. Organoleptic evaluation of low fat probiotic (*Lactobacillus acidophilus*) beverage prepared by whey and sorghum. The Pharma Innovation. 2017b;6:153. .
52. Morya S, Kumari J, Menaa F. Inflammatory Bowel Disease at the Time of COVID-19: Beyond Nutritional Aspects. EC Gastroenterology and Digestive System. 2021;8:10-19.
53. Natt SK, Katyal P. Current trends in non-dairy probiotics and their acceptance among consumers: A Review,

Agricultural Reviews. 2021;39:31.
54. Olivares A, Soto C, Caballero E, Altamirano C. Survival of microencapsulated *Lactobacillus casei* (prepared by vibration technology) in fruit juice during cold storage. Electronic Journal of Biotechnology. 2019;42:42-48.
55. Pakbin B, Razavi SH, Mahmoudi R, Gajarbeygi P. Producing probiotic peach juice. Biotechnology and Health Sciences. 2014.
56. Paredes-Toledo J. Roasted chickpeas as a probiotic carrier to improve *L. plantarum* 299v survival during storage. Lebensmittel-Wissenschaff and Technologie. 2021;146:111471.
57. Peerajan S, Chaiyasut C, Sirilun S, Chaiyasut K, Kesika P, Sivamaruthi BS. Enrichment of nutritional value of *Phyllanthus emblica* fruit juice using the probiotic bacterium, *Lactobacillus paracase*i HII01 mediated fermentation. Food Science and Technology. 2016;36:116-123.
58. Pendharkar S, Brandsborg E, Hammarström L, Marcotte H, Larsson PG. Vaginal colonisation by probiotic lactobacilli and clinical outcome in women conventionally treated for bacterial vaginosis and yeast infection. Bio Med Central Infectious Diseases. 2015;15(1):1-12.
59. Petricevic L, Domig KJ, Nierscher FJ, Sandhofer MJ, Fidesser M, Krondorfer I. Characterisation of the vaginal Lactobacillus microbiota associated with preterm delivery. Scientific Reports. 2014;4(1):1-6.
60. Qamer S, Deshmukh M, Patole S. Probiotics for cow's milk protein allergy: a systematic review of randomized controlled trials. European Journal of Pediatrics. 2019;178(8):1139-1149.
61. Ranadheera CS, Vidanarachchi JK, Rocha RS, Cruz AG, Ajlouni S. Probiotic delivery through fermentation: Dairy vs. non-dairy beverages. Fermentation. 2017;3(4):67.
62. Rasika DM, Vidanarachchi JK, Rocha RS, Balthazar CF, Cruz AG, Sant Ana AS. Plant-based milk substitutes as emerging probiotic carriers. Current Opinion in Food Science. 2021;38:8-20.
63. Ravindran S, Radhai Sri S. Probiotic oats milk drink with microencapsulated *Lactobacillus plantarum*: An alternative to dairy products. Nutrition & Food Science. 2020.
64. Salmerón I. Fermented cereal beverages: From probiotic, prebiotic and synbiotic towards Nanoscience designed healthy drinks. Letters in Applied Microbiology. 2017;65(2):114-124.
65. Salmerón I, Thomas K, Pandiella SS. Effect of potentially probiotic lactic acid bacteria on the physicochemical composition and acceptance of fermented cereal beverages. Journal of Functional Foods. 2015;15:106-115.
66. Sanders ME, Merenstein D, Merrifield CA, Hutkins R. Probiotics for human use. Nutrition Bulletin. 2018;43(3):212-225.
67. Santos MA, Costa GM, Dias SS, Klososki SJ, Barão CE, Gomes R. Pasteurised sugarcane juice supplemented with *Lactobacillus case*i and prebiotics: physicochemical stability, sensory acceptance and probiotic survival. International Food Research Journal. 2019;26(4):1315-1325.
68. Sarkar S. Potentiality of probiotic yoghurt as a functional food–a review. Nutrition & Food Science. 2018;49(2):182-202.
69. Seminario-Amez M, López-López J, Estrugo-Devesa A, Ayuso-Montero R, Jané-Salas E. Probiotics and oral health: A systematic review. Medicina oral, Patologia oral y cirugia bucal. 2017;22(3):e282.
70. Shori AB. The potential applications of probiotics on dairy and non-dairy foods focusing on viability during storage. Biocatalysis and Agricultural Biotechnology. 2015;4(4):423-431.
71. Shori AB. Influence of food matrix on the viability of probiotic bacteria: A review based on dairy and non-dairy beverages. Food Bioscience. 2016;13:1-8.
72. Sperry MF, Silva HL, Balthazar CF, Esmerino EA, Verruck S, Prudencio ES. Probiotic Minas Frescal cheese added with *L. casei* 01: Physicochemical and bioactivity characterization and effects on hematological/ biochemical parameters of hypertensive overweighted women: A randomized double-blind pilot trial. Journal of Functional Foods. 2018;45:435-443.
73. Sridharan S, Das KMS. A study on suitable non-dairy food matrix for probiotic bacteria: A systematic review. Current Research in Nutrition and Food Science Journal. 2019;7(1):05-16.
74. Suvarna S, Dsouza J, Ragavan ML, Das N. Potential probiotic characterization and effect of encapsulation of probiotic yeast strains on survival in simulated gastrointestinal tract condition. Food Science and Biotechnology. 2018;27(3):745-753.
75. Tesfaye W, Suarez-Lepe JA, Loira I, Palomero F, Morata A. Dairy and nondairy-based beverages as a vehicle for probiotics, prebiotics, and symbiotics: Alternatives to health versus disease binomial approach through food. In Milk-based Beverages. Woodhead Publishing. 2019;9:473-520.
76. Tester RF, Al-Ghazzewi FH. Role of prebiotics and probiotics in oral health. Nutrition & Food Science. 2018.
77. Turkmen N, Akal C, Özer B. Probiotic dairy-based beverages: A review. Journal of Functional Foods. 2019;53:62-75.
78. Ulpathakumbura CP, Ranadheera CS, Senavirathne ND, Jayawardene LPINP, Prasanna PHP, Vidanarachchi JK. Effect of bio preservatives on microbial, physico-chemical and sensory properties of Cheddar cheese. Food Bioscience. 2016;13:21-25.
79. Vasile A, Corcionivoschi N, Bahrim G. The prebiotic and protective effects of buckwheat flour and oat bran on *Lactobacillus acidophilus.* The Annals of the University of Dunarea de Jos of Galati. Fascicle VI. Food Technology. 2016;40(2):40.
80. Valero-Cases E, Frutos MJ. Effect of Inulin on the Viability of *L. plantarum* during Storage and *in vitro* Digestion and on Composition Parameters of Vegetable Fermented Juices. Plant Foods for Human Nutrition. 2017;72:161–167.
81. Vijaya Kumar B, Vijayendra SVN, Reddy OVS. Trends in dairy and non-dairy probiotic products-a review. Journal of Food Science and Technology. 2015;52(10):6112-6124.
82. Walsh J, Meyer R, Shah N, Quekett J, Fox AT. Differentiating milk allergy (IgE and non-IgE mediated) from lactose intolerance: understanding the underlying mechanisms and presentations. British Journal of General Practice. 2016;66(649):e609-e611.
83. Yong SJ, Tong T, Chew J, Lim WL. Antidepressive mechanisms of probiotics and their therapeutic

potential. Frontiers in Neuroscience. 2020, 1361.
84. Žuntar I, Petric Z, Bursać Kovačević D, Putnik P. Safety of probiotics: functional fruit beverages and nutraceuticals. Multidisciplinary Digital Publishing Institute-Foods. 2020;9(7):94.