Dairy and non-dairy based probiotics: A review

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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 amylovorus, 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 bacteriocins (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 (lipoholicity) (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].

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

<table>
<thead>
<tr>
<th>Dairy-based probiotics</th>
<th>Organisms used</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koumiss</td>
<td>Lactobacilli, Non-lactose-fermenting yeasts</td>
<td>Turkmen et al., 2019 [77]</td>
</tr>
<tr>
<td>Kefir</td>
<td>Lactobacillus kefir</td>
<td>Kandylis et al., 2016 [50]</td>
</tr>
<tr>
<td>Yogurt</td>
<td>Lactobacillus bulgaricus, Streptococcus thermophilus</td>
<td>Sarkar, 2018 [58]</td>
</tr>
<tr>
<td>Butter milk</td>
<td>Lactococcus lactis, Lactobacillus bulgaricus</td>
<td>Ranadheera et al., 2017 [68]</td>
</tr>
<tr>
<td>Bifidus milk</td>
<td>Bifidobacterium bifidum, Bifidobacterium longum</td>
<td>Khorsbidian et al., 2020 [39]</td>
</tr>
<tr>
<td>Acido- bifidus milk</td>
<td>Lactobacillus acidophilus, Bifidobacterium sp.</td>
<td>Hati et al., 2017 [33]</td>
</tr>
<tr>
<td>Whey and sorghum beverage</td>
<td>Lactobacillus acidophilus, Lactobacillus casei, Lactobacillus rhamnosus</td>
<td>Morya et al., 2017a, Morya et al., 2017b [50,51]</td>
</tr>
<tr>
<td>Whey beverage</td>
<td>Bifidobacterium lactis, Lactobacillus acidophilus</td>
<td>Shori, 2015 [70]</td>
</tr>
<tr>
<td>Fermented skim milk</td>
<td>Lactobacillus acidophilus, Bifidobacterium animalis subsp. Lactis</td>
<td>Ranadheera et al., 2017 [58]</td>
</tr>
<tr>
<td>Cheddar cheese</td>
<td>Lactobacillus lactis subsp. lactis, Lactobacillus helveticus, Streptococcus thermophilus, Lactobacillus rhamnosus</td>
<td>Ulpathakumbura et al., 2016 [78]</td>
</tr>
<tr>
<td>Minas cheese</td>
<td>Lactobacillus paracasei, Lactococcus subsp. Streptococcus thermophilus</td>
<td>Sperry et al., 2018 [72]</td>
</tr>
</tbody>
</table>

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 monosaccharides 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) [62, 13].

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 cardiac, gastrointestinal and respiratory signs and symptoms. Reactions mediated to skin, cardiac, gastrointestinal and respiratory signs and symptoms 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 cardiac, gastrointestinal and respiratory signs and symptoms.

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>
<thead>
<tr>
<th>Probiotics</th>
<th>Probiotic microorganisms</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oat flour, milk</td>
<td>Lactobacillus plantarum Bifidobacterium lactis</td>
<td>Ravindran and Radhaisri, 2020 [63], Asazdadeh et al. 2021 [8]</td>
</tr>
<tr>
<td>Wheat, millet, maize milk or flour</td>
<td>Lactobacillus plantarum, Lactobacillus acidophilus, Lactobacillus fermentum, Lactobacillus coprophilus, Leuconostoc reffinolactis, Leuconostoc mesenteroides, Lactobacillus brevis, Saccharomyces cerevisiae, Candida tropicalis, Candida glabrata, Geotrichum penicillatum, Geotrichum candidum</td>
<td>Tesfaye et al., 2019 [75]</td>
</tr>
<tr>
<td>Sorghum, ragi flour</td>
<td>Leuconostoc, Enterococcus and Lactobacillus brevis</td>
<td>Salmeron et al., 2015</td>
</tr>
<tr>
<td>Wheat flour, malt</td>
<td>Lactococcus lactis</td>
<td>Raskia et al., 2021 [52]</td>
</tr>
<tr>
<td>Soymilk</td>
<td>Bifidobacterium animalis, Lactobacillus acidophilus, Kluyveromyces marxianus, Kluyveromyces lactis, Lactobacillus brevis, Lactobacillus kefir</td>
<td>Sridharan and Das, 2019 [73], Kumari et al., 2018 [43]</td>
</tr>
<tr>
<td>Buckwheat and oat</td>
<td>Lactobacillus acidophilus</td>
<td>Vasile et al., 2016 [79]</td>
</tr>
<tr>
<td>Gowé</td>
<td>Lactobacillus fermentum, Lactobacillus mucosae, Pediococcus acidilactici, and Weisella confusa</td>
<td>Emujugha and Badejo, 2017 [21]</td>
</tr>
<tr>
<td>Peanut-soy milk</td>
<td>Pediococcus acidilactici, Lactobacillus lactis, Lactobacillus rhamnosus, Lactobacillus acidophilus.</td>
<td>do Amaral Santos et al., 2014 [48]</td>
</tr>
<tr>
<td>Chickpea milk</td>
<td>Lactobacillus plantarum</td>
<td>Paredes-Toledo, 2021 [56]</td>
</tr>
<tr>
<td>Quinoa milk</td>
<td>Lactobacillus plantarum Bifidobacterium longum</td>
<td>Ayub et al., 2021</td>
</tr>
<tr>
<td>Buckwheat, dark buckwheat milk</td>
<td>Lactobacillus rhamnosus, Lactobacillus plantarum</td>
<td>Kockova and Valik, 2014 [40], Matejcikova et al., 2017</td>
</tr>
<tr>
<td>Ogi</td>
<td>Saccharomyces Cerevisiae and Bacillus sp.</td>
<td>Kohajdova, 2017</td>
</tr>
<tr>
<td>Buckwheat</td>
<td>Lactobacillus plantarum</td>
<td>Ilango and Antony, 2021 [55]</td>
</tr>
</tbody>
</table>
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 LDL-P, 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 improve 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) [53]. 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) [38].

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 kefir, 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

Fruit Juice Based Probiotics

<table>
<thead>
<tr>
<th>Fruit Juice</th>
<th>Lactobacillus paracasei</th>
<th>Lactobacillus plantarum</th>
<th>Lactobacillus rhamnosus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple juice</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pine apple juice</td>
<td>Lactobacillus rhamnosus, Lactobacillus casei, Lactobacillus paracasei</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mango juice</td>
<td>Lactobacillus casei</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raspberry juice</td>
<td>Lactobacillus casei</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orange juice</td>
<td>Lactobacillus acidophilus, Bifidobacterium bifidum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amla juice</td>
<td>Lactobacillus paracasei</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peach Juice</td>
<td>Lactobacillus casei, Lactobacillus delbrueckii</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweet lemon juice</td>
<td>Lactobacillus plantarum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugarcane juice</td>
<td>Lactobacillus casei</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Watermelon juice</td>
<td>Lactobacillus plantarum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mosambi juice</td>
<td>Saccharomyces cerevisiae, Wickerhamomyces anomalous, Pichia Barkeri, Yarrowia lipolytica</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetable based probiotics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pumpkin</td>
<td>Lactobacillus casei</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Artichoke</td>
<td>Lactobacillus casei</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabbage juice</td>
<td>Lactobacillus casei</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broccoli</td>
<td>Lactobacillus bulgaricus, Streptococcus thermophiles, Lactobacillus acidophilus, Bifidobacterium bifidum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turnip</td>
<td>Lactobacillus fermentum, Lactobacillus Paracasei, Lactobacillus plantarum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ghaempanah et al., 2020</td>
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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 overgrowth 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 Lactobacillus 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 bacterial vaginosis (BV) (Petricovic 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 vaginal 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 diarrhea, depression, kidney related problems and antimicrobial resistance (Petricovic 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 Bifidobacterium, 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).

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
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