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Probiotic foods: Health booster

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Abstract
Probiotic bacteria have become increasingly popular during the last two decades as a result of the continuously expanding scientific evidence pointing to their beneficial effects on human health. As a result they have been applied as various products with the food industry having been very active in studying and promoting them. Within this market the probiotics have been incorporated in various products, mainly fermented dairy foods. In light of this ongoing trend and despite the strong scientific evidence associating these microorganisms to various health benefits, further research is needed in order to establish them and evaluate their safety as well as their nutritional aspects. The purpose of this paper is to review the current documentation on the concept and the possible beneficial properties of probiotic bacteria in the literature, focusing on those available in food.

Keywords: Probiotics, Benefits, *Lactobacillus*, Health Benefits, Non dairy probiotics

1. Introduction
Probiotics have a long history of human use and are traditionally consumed in several parts of the world. The root of the word 'probiotic' from Greek word pro meaning promoting and biotic meaning life together means 'for promoting life'.
In 1953, the term probiotics was first coined by Werner Kollath. In 1965 Lily & Stillwell introduced the term "probiotic" & defined it as substances produced by microorganisms which promote growth of other microorganism. Probiotics are bacteria and the successful growth of these organisms depends on indigestible carbohydrates that are available in different plants and fruits. Nutrients that are needed for the survival of probiotics are called 'prebiotics'.
High profile probiotic –containing products have been hugely successful in Europe. Most of the probiotics fall into group of organisms known as lactic acid producing bacteria.

2. Definition
According to FAO/WHO (2006) [9] Probiotics are live microorganisms which when administered in adequate amount confer health benefits on the host
International Life Science Institute Europe defines probiotics as "a live microbial food ingredient that, when ingested in sufficient quantities, exerts health benefit on the consumer.
Marteau *et al* (2001) [20] defined probiotics as microbial cell preparations or compacts of microbial cells that have a beneficial effect on the health and well being.
Probiotics are microorganisms, basically bacteria that when ingested would confer health benefit beyond the basic nutrition (De Vrese *et al*., 2008) [6].
Probiotics are typically naturally occurring microbes such as those used in foods or isolated from humans or animals or microbes that have been genetically altered for a specific effect (Sanders, 2008) [33]

(a) What are Probiotics?
Probiotics are live microbes that can be formulated into many different types of products, including foods, drugs and dietary supplements. Species of Lactobacillus and Bifidobacterium are most commonly used as probiotics, but yeast (Saccharomyces *cerevisiae*), E. *coli* are also used as probiotics. Lactic acid bacteria, including Lactobacillus species, used for preservation of food, serve a dual function by acting as agent for food fermentation and imparting health benefits.

Prebiotics are non digestible substances that provide beneficial physiological effect for the host by selectively stimulating the favourable growth or activity of a limited number of indigenous bacteria. Prebiotics are used as food ingredients in biscuits, cereals, chocolates, spreads and dairy products. Commonly known prebiotics are oligofructose, inulin, Galacto-oligosaccharide, lactulose, breast milk oligosaccharides (Guarner, 2008) [13].

Synbiotics are products that contain both probiotic and prebiotics. Synbiotics exert both probiotic and prebiotic effect (Guarner, 2008) [13].

3. Characteristics / Properties of Probiotics

Certain important physiological characteristics may be important for probiotics targeted towards particular applications. For example, resistance to stomach acid, pancreatic secretions such as bile and digestive enzymes important for probiotics needing to survive in high numbers through the small intestine. Properties of a good probiotics is safety, performance and technological properties (Fuller, 2001) [10].

Taumola *et al* (2001) [38] reported that good probiotics should be capable of exerting a beneficial effect on the host, non-pathogenic and non-toxic, should be present in large numbers in viable cells, should be capable of surviving and metabolizing in the gut environment.

According to Wright and Axelisson (2000) characteristics of probiotics will determine their ability to survive the upper digestive tract and to colonize in the intestinal lumen and colon for an undefined time period

Arora *et al* (2012) [1] opined that probiotic preparations should be GRAS (Generally Safe Regarded as Safe) and should be resistant to bile, hydrocholoric acid and pancreatic juice. They exhibit anti carcinogenic activity, stimulate immune system, reduce intestinal permeability, produce lactic acid, able to survive both acidic condition of stomach and alkaline condition of the duodenum.

4. Probiotic Organisms

Most widely used probiotic oraganisms in foods and supplementations include

i) *Bifidobacterium*:- Include bifidum and longum strains Control mineral Absorption and regulation of other bacteria.
ii) Enterococcus *faecium*:-Affect cholesterol and help to relieve symptoms associated with antibiotic diarrhea.
iii) Streptococcus *thermophilus*:-Helps in digesting lactose

5. Survival & Viability of probiotic culture

According to Champagne *et al* (2005) [2] seven factors that affect the survival of probiotics are type and form of the culture, the amount of bacteria required to obtain a beneficial effect on viability, the determination of probiotic cells in the product, stability during storage and possible change in the sensory properties.

Corrales *et al* (2007) [5] reported compatibility and adaptability between the selected strain and food used as a carrier is fundamental of a probiotic and represent a significant technological challenge. Probiotic bacteria generally do not grow well in milk and are adversely affected by storage conditions in some dairy products. (Champagne *et al*., 2008) [3]

Lactobacilli strain showed a good cellular stability maintaining constant concentration throughout the storage period regardless of final pH. (Donker *et al*., 2008) [8].

To have a positive effect on health, probiotics in food should remain viable during storage and gastrointestinal transit. Bacteria may lose their cultivability but still may be viable (Shinde, 2012) [36].

Viability of probiotic is reduced as a result of their exposure to high temperature, oxygen, low pH and light (Chen and yao 2002).

Methods for improving probiotics viability are gene modification, immobilization, two-step fermentation, use of oxygen, impermeable containers and microencapsulation (Ozer *et al*., 2010)

6. Dosage

The dose of probiotics is usually expressed as the number of colony forming units (CFUs) which is a way of expressing the number viable microbes per serving or dose.

The required dose of probiotics may vary greatly for different strains and the specific health effect under investigation with efficacious doses ranging from 50 million to more than 1 trillion CFU/day (Sanders, 2008) [33].

Accordingly studies documenting the efficacy of specific strains at a specific dosage cannot be used as evidence to support health effects at a lower dosage and the dose listed as the label must be based on studies that show a health effects in human.

7. Mode of action of probiotics

Probiotics are bacteria that interfere and kill pathogens but the mechanisms employed by these agents in preventing infection and disease vary from host to host.

Probiotics act mainly by three mechanisms. They are direct interaction with disease causing microbes; beneficial bacteria compete with disease developing microbes for nutrition, strengthen the immune system and help prevent disease.

Some microorganisms modulate glycosylation of the intestinal mucus and to reduce the production of antimicrobials by the mucosa, revealing proposed mechanisms where by intestinal microbes may influence the gut micro-ecology and shape the immune system. (Shinde *et al*., 2012) [36]

According to Oelschlaeger (2010) [21] three modes of actions of i) Probiotics may be able to modulate the host's defences including the inmate as well as the acquired immune system. ii) Probiotics can have direct effect on other microorganisms, and or pathogenic ones. iii) Probiotic effects may be based on action affecting microbial products like toxins and host products like bile salts and food ingredient.

Sanders (2008) [33] reported probiotics can modify the surrounding environment by modulating the pH and or the oxidation reduction potential, which may compose the ability of pathogens to become established. Finally probiotics may provide beneficial effects by stimulating non-specific immunity and modulating the harmful and cellular immune response.

Some of the probiotics particularly lactic acid bacteria inhibit the growth of the pathogens by creating an acidic environment through the production of organic acid. (Ogava *et al*., 2001) [22]

Probiotics have various mechanisms of action although the exact manner in which they exist their effects is still not fully elucidated. These range from bacteriocin and short chain fatty acid production, and produces lowering of gut pH and nutrient (Guarner, 2003) [12]. Probiotic bacteria cultures encourage growth of beneficial micro organism and crowd out potentially harmful bacteria there by reinforcing the body's natural defence mechanism. (Saarela *et al*., 2000) [29]

According to Yao *et al* (2002) [48] Probiotic effect is accredited

to the production of metabolic by product such as acid, hydrogen peroxide, bacteriocin etc. Diaz *et al* (2003) found that probiotics enhance intestinal epithelial barrier functions by increasing the production of mucin, preventing injury of the epithelium from pathogens and reducing cell permeability. They may also enhance the mucosal barrier function by inducing expression of antimicrobial peptides like defensins.

8. Benefits of probiotics

A) Nutritional Benefits

The action of microorganisms during the preparation of cultured foods or in the digestive tract has been shown to improve the quantity, availability and digestibility of some nutrients. Niacin and riboflavin levels in yogurt are increased with fermentation

Ingestion of probiotics is associated with improved production of riboflavin; niacin, thiamine, vitamin B6, vitamin B12, and folic acid. Probiotics play a role in increasing bioavailability of calcium, iron, manganese, copper phosphorous and increase the digestibility of protein and fat in yogurt.

Microbial action in the gut, specifically by beneficial cultures, has been shown to enhance the bioavailability and digestibility of certain nutrients and also the organic acids such as acetate and lactate produced during fermentation by LAB lower the pH of intestinal contents there by creating undesirable conditions for harmful bacteria. (Parvez, 2006) [25]

B) Therapeutic Benefits

Probiotics are intended to assist the body's naturally occurring gut microbata. The major health benefits of probiotics are 1) Enhanced immune system 2) Reduces negative effects of taking many types of antibiotics. 3) Aids in preventing and treating colon inflammation following surgery.4) Increased ability to digest food. 5) Helps to prevent eczema in youth. 6) Therapeutic for viral respiratory tract infections by enhancing the overall immune system.7) Reduce lactose intolerance 8) Reduces incidence of yeast infections, vaginitis and candidiasis 9) Increases ability to assimilate the nutrients from food.10) Alleviates many common digestive disorders such as constipation, diarrhea and IBS.11) Act as a remedy for bad breath (halitosis) 12.) Increases ability to synthesise vitamin B. 13) Increases ability to absorb calcium.14) Promotes anti-tumor and cancer activity in the body. Hence the intake of probiotics in the daily diet will provide the health benefit.

i) Lactose Intolerance

Lactose is a sugar found in milk. Lactose intolerance is a condition of in which milk sugar is not digested. It occurs generally in infants & children caused by beta-galactosidase depletion. L. *acidophilus* and bifidobacteria have been shown to improve digestion of lactose.

Lactic acid of the yoghurt alleviates the symptoms of lactose intolerance in lactase –deficient individuals. The beneficial effect appears to be a consequence of the lactic acid bacteria in fermented milk increasing lactase activity in the small intestine.

Tuoky *et al* (2003) [39] reported probiotic bacteria contain high level of lactase which is released within the intestinal lumen, when these bacteria are lysed by bile secretions. Lactase then act on the ingested lactose decreasing maldigestion symptoms.

The most investigated health effects of probiotics is the enhancement of lactose digestion and the avoidance of intolerance symptoms in lactose malabsorption, namely persons with an sufficient activity of lactose cleaning enzyme B-galactosidase in the small intestine. Fermented milk contains probiotics that survive in the passage through the stomach, to be fully deposited in the small intestine to support lactose hydrolysis by its own enzymes (De Vrese *et al*., 2008) [6].

ii) Diarrhea

The well known uses of probiotics are for diarrhoeal diseases prevention and management of acute viral and bacterial diaarhoea as well as the control of antibiotic resisted diarrhea. Probiotics can prevent or ameliorate diarrhea through their effects on the immune system.

The ability of Probiotics to decrease the incidence or duration of certain diarrheal illnesses is the most substantiated health effect of probiotics. Lactobacillus is safe and effective as a treatment for children with acute infectious diarrhea.

Some probiotics have been shown in preliminary research to treat various forms of gastroenteritis. They might reduce duration of illness and the frequency of stools. Fermented milk products also reduce the duration of symptoms.

Incidence of antibiotic associated diarrhea caused by clostridium *difficile* and rotavirus diarrhea can also be reduced by administration of probiotics (Vasiljevic, 2008) [41].

In the paediatric population, probiotics appear to benefit viral diarrhea, possibly by increasing secretory IgA and decreasing viral shedding, suggesting an immunological mechanism.

a) Acute Diarrhea

In the prevention of adult and childhood diarrhea, Lactobacillus GG, L. casei DN-114 001 and *S. boulardiii* are effective. (Guarner, 2008) [13]

b) Antibiotic associated diarrhea

Antibiotic associated diarrhea results from an imbalance the colonic microbata caused by antibiotic therapy. Microbata alteration changes carbohydrate metabolism with decreased short term fatty acid absorption and an osmotic diarrhea as a result.

S. boulardiii or L. rhamnosus GG are effective in adult or children who are receiving antibiotic therapy. *L. casei* DN-114001 is effective in hospitalized patients for preventing antibiotic associated diarrhea.

iii) Inflammatory Bowel Disease (IBD) & Irritable Bowel Syndrome

Probiotic administration either through regulation of the inflammatory response, enhancing barrier function to prevent the invasion of tight junctions or modulation of gut microbata composition and or activity might bring about relief in IBD symptoms or maintain remission from symptoms. (Santosa *et al*., 2006) [35]

Alteration of normal intestinal micro flora plays an important role in the pathogenesis of inflammatory bowel disease. Hence it seems intuitive that replenishing or modifying the micro flora with probiotic administration may prevent or treat this disease.

a) Pouchitis

Pouchitis is defined as acute or chronic inflammation of the ileal reservoir created after colectomy and ileal pouch-anal anastomosis.

Probiotics prevent initial attack of pouchitis and prevent further relapse of pouchitis after induction of remission with antibiotics. Probiotics can be recommended to patients with pouchitis of mild activity. (Guarner, 2008) [13]

b) Ulcerative Colitis

The several probiotic compounds have shown promise in the therapy of ulcerative colitis. Bifidobacteria fermented milk has been found to decrease the rate of relapse in a small study. In mild to moderate ulcerative colitis, Saccharomyces *boulardii* given for 4 weeks induced remission in 17 to 24 patients. (Guarner, 2008) [13].

The probiotic *E. coli* Nissle strain equivalent to mesalazine in maintaining remission of ulcerative colitis.

A reduction in abdominal bloating and flatulence as a result of probiotic treatments. Lactobacillus *reuteri* may improve colicky symptoms within one week of treatment. Certain probiotics improve the principal symptoms in person with IBS.

iv) Helicobacter Pylori

Lactobacilli and bifidobacterial strains, as well as Bacillus *clausii* reduce the side effect of antibiotic therapies and improve patient compliance. Supplementation of anti-H. pyroli antibiotic regimens with probiotics effective in increasing eradication rates. Probiotics are helpful as adjuvant therapy with antibiotics in the eradication of H. pylori infections. (Guarner, 2008) [13].

Studies suggest that probiotic supplementation increased the irradication rate and reduced the side effects. Production of inhibitors by probiotic bacteria, in fermented milks, against ulcerative Helicobacter pylori.

v) Hepatic Diseases

Hepatic Encephalopathy is a liver disease its effects are life threatening. The exact pathogenesis of HE still remains unknown. The probiotics strep. *thermophilus*, Bifidobacteria, L. *acidophilus*, L. *plantarum* L. *casei*, L. *delbruekkii bulgaricus* and *E. faecum* containing therapeutic effect have multiple mechanisms of actionthat make them superior to conventional treatment and lower portal pressure with a reduction in the risk of bleeding.

vi) Constipation

Constipation, a disorder of motor activity of the large bowel Characterized by bowel movements that are less frequent than normal, pain during defecation abnormal swelling and incomplete emptying of colon contents can be relieved by probiotic use.

A majority of the clinical trials reviewed showed that lactic acid bacteria alleviate abdominal pain and discomfort. Both single and multi centre studies have shown that lactic acid bacteria may improve abdominal bloating and distension. (Guarner, 2008) [13]

vii) HIV and Immune function

Exposure to foreign antigens elicits a complex cascade of responses from the human body including launching protective reactions against food antigens and colonizing micro flora.

The immune response may further be enhanced when one or more probiotics are consumed together and work synergistically. The immune system is extremely complex involving both cell-based and antibody based responses.

Sanders (2007) [32] reported that probiotic cultures enhance levels of certain immune reactive cells and also probiotics provide a additional tool to help our body to protect itself.

Probiotics shown to have immunomodulatory properties through the inhibition of bacterial translocation, stimulation of phagocytes, macrophages and natural killer cells, increased proliferation in organs of the immune system and increased levels of cytokines. (De Vrese, 2008) [6]

Probiotic bacteria are able to enhance both specific and non-specific immune response by activating macrophages increasing levels of cytokine, increasing level of immunoglobulin's especially IgA.

viii) Cancer

In general cancer is caused by mutation or activation of abnormal genes that control cell growth and division.

Probiotics were shown to posess antimutagenic and anticarcinogenic activity against well-known mutagens and promutagens although the mechanisms are still unknown. They can decrease levels of cellular enzymes responsible for the activation of pro carcinogens. Alternatively microbes can be involved in the metabolism of substance or into the prevention of their binding to the cell surface. (Rafter, 2003).

Probiotic cultures decrease the exposure chemical carcinogens by detoxifying ingested agents, altering the environment of the intestine and thereby decreasing population or metabolic activities of bacteria, producing metabolic products, producing inhibit growth of tumor cells, stimulating immune system to defend against cancer proliferation.

Probiotic bacteria able to counteract mutagenic and geotaxis effects in the colon and other organ sites. Probiotics play an important role in the prevention of cancer by detoxifying ingested carcinogens, altering the environment of the intestine and thereby decreasing population to inhibit the growth of tumor cells, stimulating immune system better defend against cancer cell proliferation (Sanders, 2007) [32].

Certain members of Lactobacillus and Bifidobacterium spp. decrease the level of carcinogenic enzymes produced by colonic flora through normalization of intestinal permeability and micro flora balance as well as production of antimutagenic organic acids and enhancement of hosts immune system. Additionally studies suggest that probiotic bacteria or their byproducts influence epithelial cell kinetics in the colon.

ix) Cholesterol

The cholesterol is essential for many functions in the human body. It acts as a precursor to certain hormones and vitamins. Although human synthesise cholesterol to maintain minimum levels for biological functioning, diet also known to play a role in serum cholesterol levels.

The use of probiotics to reduce the risk of hypercholestremia seems very effective specially if consumed as a part of normal daily nutrition. L. acidophilus have high rate of cholesterol lowering effect. (Vasiljevic. 2008) [41]

Several mechanisms have been hypothesized which include enzymatic deconjugation of bile acids by bile salts hydrolase of probiotics, assimilation of cholesterol by probiotics, co-precipitation of cholesterol with deconjugated bile, incorporation of cholesterol into the cellular membranes of probiotics during growth and conversion of cholesterol into coprostanol. (Liong and Ooi, 2010) [19]

x) Heart Diseases & Hypertension

Dietary recommendations accompany more aggressive strategies to control hypertension, and food products derived from probiotic bacteria could possibly contribute to blood pressure control.

Lactobacillus helveticus and Sacc. cerevisiae reduces systolic and diastolic pressure. Regular consumption of probiotics may provide a modest prophylactic effect against heart disease (Guarner, 2008) [13]

Sanders, (2007) [32] found that consumption of lactobacilli or products made from them may reduce blood pressure in mildly hypertensive people.

xi) Allergy

The prevalence of allergic diseases has increased over the last 35-40 years particularly in western societies. Probiotic bacteria are important in regulating inflammation associated with hypersensitivity reactions in patients with atopic eczema and food allergy. Probiotics are also helpful in alleviating some of the symptoms of food allergies such as those associated with milk proteins.

Exposure to bacteria in early life may exhibit a protective role in allergy and probiotics may provide safe alternative microbial stimulation needed for the developing immune system in infants. Breakdown of intestinal mucosal barrier function, allowing extensive antigen challenge may be factors in some allergic conditions.

Hereditory allergic conditions of increasing importance in developing countries such as eczema, asthma, atopic dermatitis and rhinitis can be treated with probiotics (Kalliomaki *et al*., 2003) [15].

xii) Infectious Diseases

Probiotics compete with pathogens for adhesion sites, strengthen the epithelial barrier by preservation of tight junction, protein expression between enterocytes and inhibition of epithelial cell apoptosis (Prassol *et al*., 2005) [24].

Probiotics are known to secrete anti microbial molecules. Currently, most beneficial effect of probiotics has been observed in studies on diarrhea, in particular rotavirus watery diarrhea (Rautava *et al*., 2006) [27].

xiii) Kidney and Pancreas

Sanders, (2007) [32] reported probiotics play a major role reducing kidney stones by improving GI tract oxalate levels and may decrease the oxalate absorption.

xiv) Post Surgery

Application of probiotics for surgical patients is not necessarily limited to skin and wounds. *L. plantarum* 299 gives with enteral fiber nutrition decreased the rate of post operative infections in liver transplant patient at very high risk of infections, organ rejection and death (Guarner, 2008) [13].

9. Applications of Probiotics in food and beverages.

Today an increase in knowledge of functional foods has led to develop foods with health benefits beyond adequate nutrition. Functional foods are also known as designer foods, medicinal foods, neutraceuticals therapeutic foods, super foods, foodiceuticals and medifoods. One way in which foods can be modified to become functional by the addition of probiotics (FAO/WHO, 2006) [9]. The presence of probiotics in commercial food products has been claimed for certain health benefits. This has led to industries focusing on different applications of probiotics in food products and creating a new generation of 'probiotic health' foods. The range of food products containing probiotic strains is wide and still growing.

New food products have been formulated with the addition of probiotic cultures. Different types of manufacturers have been used such as various types of cheese, ice-creams, milk based desserts etc (Saarela *et al*., 2000)

A) Dairy based probiotic foods

Milk and its products is good vehicle of probiotic strains. Dairy products play important role in delivering probiotic bacteria to human. Probiotics can be found in a wide variety of commercial dairy products including sour and fresh milk, yogurt, cheese, etc.

Dairy products play important role in delivering probiotic bacteria to human, as these products provide a suitable environment for probiotic bacteria that support their growth and viability (Saarela *et al*., 2000)

Several factors need to be considered in dairy products such as viability of probiotics in dairy, the physical, chemical and organoleptic properties of final products, the probiotic health effect and the regulations and labeling issues. (Krock, L. 2006) [18]

i) Drinkable fresh milk and Fermented Milk

Among probiotics carrier food products, dairy drinks were the first commercialized products that are still consumed in larger quantities than other probiotic beverages.

Functional dairy beverages can be grouped into two categories: fortified dairy beverages (including probiotics, prebiotics, fibers, polyphenols, peptides, sterol, stanols, minerals, vitamins and fish oil), and whey-based beverage. (Ozer, 2010) [23]

Factors affecting the viability of probiotic cultures in fermented milks. Acidity, pH, dissolved oxygen content, redox potential, hydrogen peroxide, starter microbes, potential presence of flavoring compounds and various additives (including preservatives) have effects during manufacturing and storage (Saarela *et al*., 2000)

ii) Yogurt

Yogurt is one of the original sources of probiotics and continues to remain a popular probiotic product today. Yogurt is known for its nutritional value and health benefits. Yogurt is produced using a culture of *L. delbrueckii* subsp. *bulgaricus* and *Streptococcus salivarius* subsp. *thermophilus* bacteria. The viability of probiotics and their proteolytic activities in yoghurt must be considered. Although yogurt has been widely used as probiotics vehicle, most commercial yogurt products have low viable cells at the consumption time.

Viability of probiotics in yogurt depends on the availability of nutrients, growth promoters and inhibitors, concentration of solutes, inoculation level, incubation temperature, fermentation time and storage temperature, strains of probiotic bacteria, pH, buffering capacity of the media as well as the storage temperature (Talwalker, 2004) [37].

Encapsulation in plain alginate beads, chitosan coated alginate, alginate-starch, alginate- prebiotic, alginate-pectin, in whey protein-based matrix, or by adding prebiotics or cysteine into yogurt, could improve the viability and stability of probiotics in yogurt. (Venugopalan, 2010) [43].

iii) Cheese

Probiotics in cheese were found to survive the passage through the simulated human gastrointestinal tract and significantly increase the numbers of probiotic cells in the gut (Ouwehand *et al*., 2009). Cheeses have a number of advantages over yogurt and fermented milks because they have higher pH and buffering capacity, highly nutritious, high energy, more solid consistency, relatively higher fat content and longer shelf life.

Fresh cheese like cottage cheese has high recommended daily intake, limited shelf life with refrigerated storage temperature. It may, thus, serve as a food with a high potential to be applied as a carrier for probiotics. High survival rate of probiotics in cheese at the end of shelf life and high viable cells (Vinderola *et al.*, 2000).

iv) Other dairy products

Other dairy products including quark, chocolate mousse, frozen fermented dairy desserts, sour cream, and ice cream can be good vehicles of probiotics. Ice creams are among the food

products with high potential for use as probiotic vehicle. (Cruz *et al*., 2009).

Sour cream was investigated as probiotic vehicle and the results showed that using sour cream as a probiotic carrier is proved feasible. (Wilson *et al*., 2004) [47]. Probiotic cultures do not modify the sensory characteristics of the ice-creams and frozen desserts also these products hold good viability for probiotics during the product storage period.

B) Non dairy based

With an increase in the consumer vegetarianism, there is high demand for the vegetarian probiotic products (Vasudha and Mishra, 2013) [42]. Nondairy food applications include soy based products, Nutrition bars, cereals, and a variety of juices as appropriate means of probiotic delivery to the consumer. The factors that must be considered in evaluating the effectiveness of the incorporation of the probiotic strains into such products are safety, the compatibility of the product with the microorganism and the maintenance of its viability through food processing, packaging, and storage conditions.

According to the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) of the U.S. National Institutes of Health, about 75% of the world population is lactose intolerant. The development of new nondairy probiotic food products is very much challenging, as it has to meet the consumer's expectancy for healthy benefits. (Stanton *et al*., 2001).

i) Vegetable based

Fermentation of vegetables has been known since ancient time. Fermented vegetables can offer a suitable media to deliver probiotics. Traditional methods of production might result in inactivation of the probiotic cultures and the use of probiotics in fermented vegetables would require low temperature storage of the products (Champagne, 2009). Some of the vegetable based probiotics are vegetable based drinks like cabbage juice, carrot juice etc.

Fermented cabbage juice supports the viability of probiotics and serves as a healthy beverage. (Yoon *et al*., 2006)

ii) Fruit based

Nowadays, there is increasing interest in the development of fruit-juice based probiotic products. The fruit juices contain beneficial nutrients that can be an ideal medium for probiotics (Tuorila *et al*., 2002) [40]. Characteristics allow the selection of appropriate strains of probiotics to manufacture enjoyable healthy fruit juice. However, the sensory impact of probiotic cultures would have different taste profiles compared to the conventional, non functional products.

Pomegranate juice was proved to be a suitable probiotic drink as results have shown desirable microbial growth and viability for *L. plantarum* and *L. delbruekii.* (Kourkoutas *et al*., 2011).

iii) Cereal Based

Cereal-based probiotic products have health-benefiting microbes. The development of new functional foods which combine the beneficial effects of cereals and health promoting bacteria is a challenging issue.

Cereals are good substrates for the growth of probiotic strains and due to the presence of non-digestible components of the cereal matrix. (Salovera, 2011) [31]. Some of the common probiotic foods we are consuming daily are Idli, Ada, Dosa.

Parameters that need to be considered in the growth probiotic microorganisms are the composition and processing of cereal grains, the substrate formulation, the growth capability and productivity of the starter culture, the stability of the probiotic strain during storage, the organoleptic properties and the nutritional value of the final product (Webb, 2002) [46]

The antioxidative activities of soya milk can be increased after fermentation by lactic acid bacteria and bifidobacteria. This led to the designing of the soyabean yogurt. (Wang *et al*., 2002) [45].

10. Safety of probiotics

Probiotics are the food grade organisms witnessing a long history of safe use. Nevertheless, their apparent safety is occasionally questioned.

One of the most important characteristics of probiotics is their safety for human health that is one of the crucial points for their selection. In particular, the characterization of a probiotic strain is based on the absence of resistance to clinical or veterinary antibiotics as well as the absence of virulence factors (Sanders, 2008) [33]

Factors important for assessing the safety of a probiotic include the method of administration, the level of exposure, the health status of the users, and the physiologic functions they are intended to perform. (Sanders, 2010) [34]

The identification of bacterial strain is necessary not only for safety reasons, but also to prove their efficacy due to the fact that different strains of the same species may exert different effects on the host.

The possible complications related to the use of probiotics could be the development of bacteriemia, sepsis or endocarditis, the toxicity and the metabolic effects on the GI tract and the possibility of transfer antibiotic resistance to the GI flora, even if bacteriemia and fungemia may occur rarely and are often related to the use of saprophytic probiotics.

The food industry needs to carefully assess the safety and efficacy of all new species and strains of probiotics before incorporating them into food products In Europe; the European Food Safety Authority has proposed a framework for the safety evaluation of microorganisms in the food chain.

11. Labeling

Appropriate labeling and heath claims are pre requisite for consumer to make a choice. In addition to the general labeling requirements under the food laws of each country necessary information should also be stated on the label. (Hiller, 2001) [14]

From a scientific perspective, the suitable description of a product as reflected on the label should include:-

- Genus and species identification, with nomenclature consistent with current scientifically recognized names.
- Strain designation.
- Viable count of each strain at the end of shelf life.
- Recommended storage conditions.
- Safety in the condition of recommended use.
- Recommended dose, based on induction of the physiological effect.
- An accurate description of the physiological effects, as far as allowable by law.

12. Future perspectives of probiotic foods

In spite of problems with dosage and viability of probiotic strains, lack of industry standardization and potential safety issues, there is obviously considerable potential for the benefits of probiotics over a wide range of clinical conditions. Ongoing researches will identify and characterize existing strains of probiotics, identifying strain specific outcomes, determine optimal doses needed for certain results and assess

their stability through processing and digestion. Gene technology will certainly play a role in developing new strains, with gene sequencing allowing for an increased understanding of mechanisms and functionality of probiotics.

Over time new food products containing probiotics will emerge such as energy bars, cereals, juices, infant formulas and cheese as well as disease specific medical foods. The establishment of standards of identity for probiotic containing food products will serve to accelerate the development and availability of these food products.

13. Conclusion

With the increasing consumer awareness regarding linkage of diet and health, research in probiotics seems a highly fascinating challenge. The uses of probiotics and their applications have shown tremendous increase in the last two decades. Probiotics can turn many health benefits to the human, animals and plants. The concept that probiotics could control the development of eukaryotic pathogens is emerging. Applications of probiotics hold many challenges. In addition to the viability and sensory acceptance, it must be kept in mind that strain selection; processing and inoculation of starter culture must be considered. Probiotics industry also faces challenges when claiming the health benefits. It cannot be assumed that simply adding a given number of probiotic bacteria to a food product will transfer health to the subject. Therapeutic approaches with probiotics could help to reduce the risks of infestation by specific parasites or complement classical parasite treatments.

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