AWARENESS OF POTENTIAL ROLE OF PROBIOTICS FOR SUSTAINABILITY IN RURAL INDIA

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Abstract
The steady increase in awareness on healthy nutrition today coupled with the wish to keep the immune system strong has seen individuals turn to nutritional supplements and functional foods. Even though there has been a rapid increase in the production of probiotic products, no study has examined what adolescents know about probiotic dairy products, their attitude, or their consumption of the product. Probiotics have been recognized and explored for over a century. Metchnikoff's pioneering work was converted into commercial reality in the 1950s, and since then many probiotics' benefits have been described. Nowadays they have already found place as a food supplement and as a preventive or curative drug. The term probiotic describes a variety of microorganisms which can colonize the host and have health improving effects on it. Since it is a natural and comparably affordable product even for people with low incomes, it could be introduced into the diet of people living in the Indian rural areas. The biggest obstacles for this are education about their use and technology to prepare them in a convenient form for domestic use. Regular use could improve the quality of live and reduce the dependence on drugs and medical expenses.
Keywords : Probiotics, sustainability, India

Introduction

Indiscriminate use of antibiotics and drugs has increased the requirement for probiotics. Under the pandemic conditions, consumption of probiotics has become more important in order to strengthen the immune system of individuals. Therefore, the use of probiotics has varied such as their addition in the foodstuff (milk, cereal, and vegetable products), vegetable juices, food supplements (liquid, tablet, capsule, and powder), or in the form of drugs (Di Lena et al., 2015). As another alternative, foods such as probiotic yogurt enriched with almond milk have also been developed (Jeske et al., 2018; Röös et al., 2018; Yılmaz-Ersan and Topçuoğlu, 2019; Grom et al., 2019; Rasika et al., 2021). The effect of probiotics on health depends on the type of probiotic culture used, and the dairy product consumed. Whey dairy beverages display health benefits associated with the bioactive peptides, antioxidant activity, and essential amino acids (Coutinho et al., 2019; Turkmen et al., 2019). Both kefir and koumiss are generally probiotic products. But probiotic is a technical concept, and when microorganisms or associated products do not meet all the requirements for probiotics including health impacts based on science evidence, they cannot be called as probiotic (Turkmen et al., 2019).

Probiotics are dietary supplements of live microorganisms thought to be healthy for the host organism when administered in adequate amounts. Their beneficial effects to the host are beyond those of basic nutrition. At first, probiotics were thought to beneficially affect the host by improving its intestinal microbial balance, thus inhibiting pathogens and toxin producing bacteria. Today specific health effects are being investigated and documented including alleviation of chronic intestinal inflammatory diseases, prevention and treatment of pathogen-induced diarrhea, urogenital infections, atopic diseases etc. A recent research also provides data on anticancer and hypocholesterolemic effects of probiotics (reviewed in Gupta and Garg 2009). The most common types of probiotic strains are Lactobacillus, Bifidobacteria, but also certain yeasts and bacilli are available (Singhi and Baranwal 2008).

Poor sanitary conditions and limited health facilities are common in rural India. Unavailability of modern medicine with concomitant outbreaks of intestinal diseases is calling for an additional simple and accessible method to improve the quality of these economically challenged people. The acceptability of probiotic dairy

products in India is high because people already consume a lot of curd, milk and cheese. In the southern parts of India traditional dairy products such as rasam are prevalent since ancient times. These are good for general nutrition but have a limited role in the improvement of digestion or serious disorders, since the bacterial strains are not selected. In the present paper we focus on health improving properties of probiotics, for which they could be recognized to find place in the diet of Indian rural people.

Current market of probiotics in India

In the present scenario, India accounts for less than 1% of the total world's market under probiotics segment. Currently, most of the probiotics products available are predominantly dahi (Indian yogurt) and a few probiotic beverages such as flavored milk, fermented and unfermented milk and butter milk. But, the market has expanded beyond these most common probiotic products and the new entrants are juices, smoothies, cereal, nutrition bars and infant/toddler formula. In India, the per capita consumption of the packaged, store-purchased variety is 300 grams, and this too is heavily skewed toward urban India (~1 kg), and is near-zero in rural India. At present, 80% of the total packaged Dahi is constituted by Amul, Mother Dairy, Nestlé and Britannia due to their distribution networks and product penetration. While, rest of the 20% is made up by strong regional players like Karnataka Cooperative Milk Producers Federation, Parag Milk & Milk Products, Himalaya International, Tirumala Milk Products, The Nilgiri Dairy Farm, and VRS Foods. With time, the international entrants such as Danone, Fonterra, etc are making their presence felt. In future, the market is going to be more competitive with the entry of major business houses such as Reliance, ITC and CavinKare (data source technopak data, 2014). The yogurt market is valued at an estimated INR 1000 crore, or ~USD 182 million, comprising organized, packaged yogurt and its varieties, packaged drinks, etc., and also the frozen yogurt service market. This is expected to grow at a CAGR of 20-25% with the expectation that it will double itself in the next three years (2017).

According to the reports of Research and Market (2014), India's probiotic market is projected to grow at a CAGR of around 19% till 2019. Functional dairy products with probiotics are promising in the Indian market, as major players engaged in offering probiotic food products in the Indian market includes Mother Dairy, Amul, Danone Yakult, Nestle, Tablets India, Dr Reddy Laboratories, Unique Biotech, Zeus Biotech, etc. Mother Dairy has the dominant position in the Indian probiotic functional food and beverage market, followed by Amul. These companies are contributing lot to probiotics dairy products and due to urban population's acceptance to these products are helping to increase companies focus to produce more and more probiotic products.

In this segment, Amul pioneered to introduce Prolife Probiotic Ice Cream, Sugar Free Prolife Probiotic Ice Cream, followed by Prolife Lassi (as sachets and in plastic cups) in 2007. In 2011, it introduced Flaavyo Fruit Yoghurt, which includes fruit-based flavors like Mango, Strawberry, Pineapple, and Vanilla, and also Mishti Doi (Sweet Curd) and in 2014, it has launched Flaavyo Frozen Yoghurt.

In this league, in 2007, Yakult Danone India Pvt Ltd (YDIPL), a 50:50 joint venture company between Japan's Yakult Honsha and The French- Danone Group, has offered yakult, a fermented milk drink which contains more than 6.5 billion beneficial bacteria (Lactobacillus casei strain Shirota) in a 65 ml bottle priced at Rs 10 and is available in the pack of 5. These bacteria reach our intestine alive and impart various health benefits. Initially, yakult was available only in Delhi and thereafter it was launched nationally in a phased manner. While, mother dairy has introduced Pro Activ Dahi and drink with a starting price of Rs. 10 and declared that their products contains dietary fiber. The company expanded the range with the introduction of a fermented milk beverage called Nutrifit in two flavors, mango and strawberry. They have a wide distribution network in Delhi and Mumbai, Saurashtra and Hyderabad. Nestle brings out a probiotic dahi called Actiplus dahi. According to the company, every 100g serve of the dahi has over 100 crore probiotics, which help the digestive system if consumed daily. Tablets India, on the other hand, has established itself as a major brand in Probiotic drug and dietary supplement market.

Danone launched its creamy stirred yogurt in 2011 to target the health-conscious population in India, in three flavors - plain sweet, strawberry, and pineapple, at outlets in Delhi/ NCR, Mumbai, Pune, Hyderabad, and Bangalore. In this direction, Britannia after a huge success of their product, Daily Fresh Dahi have entered with a pioneered product in this segment by launching flavored yogurt in three flavors, mango, vanilla and strawberry fortified with 5 active nutrients, viz,, iron, iodine, calcium, zinc and vitamin A. This product is available in Mumbai, Delhi, and Bangalore.à

The market for products containing probiotics is expected to grow as Indians become more aware of natural, healthy ingredients in foods. The probiotics were launched in India in 2007 and at present the Indian probiotic industry is valued more than $10 million. In current scenario, the Indian market's contribution to the world's demand for probiotics, however, is less than one per cent in terms of turnover. The Indian probiotic industry is miniscule and at a very burgeoning stage. Currently, it stands at about Rs 50 crore and is growing at 20 per cent." Major pharmaceuticals companies have become active and are trying to formulate newer drugs and products, and packaged products like probiotic-based nutritional supplements with special needs such as lactation, pregnancy, immunodeficiency etc and products especially for pediatric and geriatric patients. In this aspect, some probiotic based pharmaceutical formulations are Sporolac, ViBact, Darolac, Biglac, Bifilac etc. Currently, probiotics are often used as animal feed supplements for cattle, poultry and piggery. This requirement is also met by importing probiotics from other countries. The most commonly found commercial probiotic drinks for human consumption are found in the form of probiotic drinks, ice creams and frozen desserts. The latest and recent addition to the list of probiotics in India is ViBact (which is made up of genetically modified Bacillus mesentricus), which acts as an alternate to B-complex capsules (Sonal et al. 2008). Probiotic products are gaining acceptance mostly in metros and in some Tier 1 cities. The Indian market is big, but difficult to reach since cold storage and cold distribution chain are underdeveloped in India, especially in the rural areas. Realizing these drawbacks, yakult has taken an initiative in this direction, and has already announced to target tier II cities in their next phase. The strongest sale of Yakult is recorded from Delhi/ NCR. In the future, it is important to increase the awareness of the country people and to educate them about the probiotics' benefits.

Intestinal tract and bacterial colonization

The intestinal mucosa surface exceeds 300 m2, and to ensure normal functions regulated homeostasis is necessary. It requires a complex interplay between the intestinal epithelial monolayer and the underlying mucosal immune system. The intestinal epithelial barrier is a dynamic system composed of a single layer of densely packed enterocytes along the villous axis of the crypt (Thomson et al 2003b; Thomson et al 2003a). Tight junctions between the cells prevent leakage through the layer. Enterocytes are highly polarized cells with apical (towards the intestinal lumen) and basolateral part (towards the body) of the membrane, the organisation which controls selected and directional transport of substrates while maintaining a barrier to pathogens (Snoeck et al 2005). The mucosal immune system provides tolerance to food antigens along with protection against pathogens. This autologous synergistic concept was recently expanded to include intestinal commensal microorganisms, which are believed to be the third and indispensable player for the normal intestinal balance (Hooper and Gordon 2001; Sansonetti 2004). Intestinal microbiota interact with the epithelial cell barrier and the mucosal immune system and it can be modulated by the use of probiotics to increase their potential in preventing and curing of diseases (Nissen et al 2009). The interaction between them has been studied using in vivo and in vitro models (Botic et al 2007).

Health-improving potential of probiotics

Modulation of the immune system

Many studies are showing immunomodulatory effects of probiotics in vitro. The response of the immune system to probiotics is weaker than in the presence of other gram positive pathogens (Veckman et al 2004). Generally, they suppress the formation of proinflammatory IL-12 while maintaining high production of

immunosuppressive cytokine IL-10 (Braat et al 2004; Hart et al 2004; Lammers et al 2003). They can also elicit non-specific immune response, like production of oxygen species and NO (Pipenbaher et al 2009). Most of the studies focused on short-term effects, while long-term consumption of probiotics has not been assessed in details with regard to sustained improvements of the immune system.

Treatment and prevention of infectious diseases

In addition to strong physical epithelial barrier, gut has additional chemical antibacterial mechanisms to control growth of potential pathogens. Plasma cells in intestinal submucosa secrete pIgA as a part of adaptive immune response (Macpherson and Uhr, 2004). Epithelial and immune cells secrete cationic antibacterial peptides: α–and β–defensins and cathelicidins (Cunliffe and Mahida 2004).

Despite the sophisticated innate and adaptive immune response, pathogens still manage to destroy or traverse the epithelial barrier and invade the host. Various in vitro experiments and clinical trials showed positive effects of probiotics in prevention and cure of intestinal pathogen induced diseases. Probiotics compete with pathogens for adhesion sites, strengthen the epithelial barrier by preservation of tight junction protein expression between enterocytes (Parassol et al 2005) and inhibition of epithelial cell apoptosis (Yan and Polk, 2002). Alternatively, they may inhance mucosal IgA-mediated immune response to pathogens (Rautava et al 2006). Furthermore, probiotics are known to secrete antimicrobial molecules. Currently, most beneficial effects of probiotics have been observed in studies on diarrhea, in particular rotavirus watery diarrhea (Szajewska and Mrukowicz 2005).

Our results showed efficacy of probiotics in other viral food and water born infectious diseases, like hepatitis viruses (unpublished results). Reports also suggest protection against Lysteria monocytogenes, Salmonella enterica and reduction of Helicobacter pylori load (Lin et al 2009), the infection which leads to chronic gastritis and increased risk of gastric malignancies. Little or no knowledge is available about the potential role of probiotics to prevent infection by uncommon enteroviruses like poliomyelitis and meningoencephalitis (Antona and Chomel 2005), the outbreaks of which are generally more frequent in the developing world.

Probiotics and prevention of necrotizing enterocolitis

Neonatal necrotizing colitis (NEC) is a challenging clinical disease entity, which is a complication of very low birth weight infants and is often fatal. The etiological cause for the disease is not understood, but it is generally accepted that the normal intestinal functions are underdeveloped in the newborn and therefore it can not deal with the challenges of dietary and microbial antigens (Lin and Stoll 2006). Several clinical studies showed that the use of probiotics significantly reduces mortality (Hunter et al. 2008, Lin et al 2008). In rural India, where pregnant women often deliver at home or in inadequately equipped facilities (Iyengar et al 2008), the use of probiotics could reduce the incidence of death along with the severity of symptoms

Prevention of allergies and inflammatory bowel diseases

Allergies and inflammatory diseases are typical western diseases closely linked to unhealthy lifestyle (hygiene hypothesis; Garn and Renz, 2007). These diseases are significantly less common among rural Indian people, also due to prevalent vegetarian food, a lot of exercise, breastfeeding and early contact with bacteria and domestic animals. These diseases are rising due to globalization in India as well. The potential role of probiotics to treat patients with allergic diseases like atopic eczema, food allergies and atopic dermatitis has not been clinically evaluated yet in detail (Bunselmeyer 2006), but reports suggest that intestinal microbiota and its diversity are different between healthy and atopic eczema affected patients (Penders et al 2007). Several lines of evidence suggest that a loss of immunological tolerance to intestinal microbiota is a major component in the etiology of inflammatory bowel diseases, like Crohn disease and perhaps also ulcerative colitis and pouchitis (Korzenik and Podolsky 2006). The most convincing data of probiotics' benefit is linked to the treatment of pouchitis (Lammers et al 2005), but little is known about treating other above mentioned diseases.

Reduction of cancer and malignant diseases

Chemical industry produces xeno-compounds with mutagenic properties, which have found numerous use in our daily-life. Since their use is widespread, they can also be detected in the food-chain. Probiotics were shown to posses antimutagenic and anticarcinogenic activity against well-known mutagens and promutagens, although the mechanisms are still unknown (Rafter 2002). They can decrease levels of cellular enzymes responsible for the activation of procarcinogens. Alternatively, microbes can be involved in the metabolism of substances or into the prevention of their binding to the cell surface (Rafter 2002).

Lactose intolerance

Although general nutrition of Indian rural population is vegetarian-based, they traditionally consume a lot of milk and milk products as an important source of proteins. Cow milk contains lactose, which is degraded after consumption into monosaccharides by β–galactosidase. The level of endogenous enzyme declines over age and causes lactose intolerance especially in the aged people, and the condition manifests with clinical symptoms such as bloating, flatulence, nausea, abdominal pain and diarrhea. Probiotic strains may decrease the symptoms by producing their own secreted β–galactosidase or by consumption of lactose during the fermentation. Dairy products could thus stay in the normal diet of the majority of population without posing the risk of health problems.

Sources of probiotics

Probiotics have been lately exploited extensively by the dairy industry as a tool for development of new competitive functional products. Traditionally, probiotics have been incorporated into yoghurt; however, a number of additional carriers appear on the market including mayonnaise, edible spreads and meat. A wide variety of species could be considered potential probiotics, but commercially used strains should have several desirable criteria: safety (lack of pathogenicity and toxicity), tolerance to harsh conditions along the digestive tract, adhesion to mucosal surface, validated and documented health effects (Morelli 2000).

Fermentation of milk in a natural way with non-selected bacterial strains would not provide substantial health benefits as described above. Since already fermented dairy products are difficult for distribution in rural India due to unreliable cold distribution chain, it would only be possible to provide people with lyophylized or spray-dried bacterial strains. To prepare an affordable and effective bacterial strain is not of interest for the industry - moreover, there are technological challenges to prepare them and to be effective starters of fermentation in the hands of final consumers.

Status of probiotics in India

Functional dairy products with probiotics are promising in the Indian market, as major players such as Amul, Yakult, Mother Dairy and Nestle launch more health drinks and yoghurts in the country (2008). The market for products containing probiotics is expected to grow as Indians become more aware of natural, healthy ingredients in foods. Probiotics are available for purchase mainly in big cities (Delhi, Bombay). According to estimates by Dairy India, the size of the dairy market is expected to grow at almost 40% annually or even more, reaching Rs 5,20,780 crores ($122,825 million) by 2011 (2008).

Currently, probiotics are often used as animal feed supplements for cattle, poultry and piggery. This requirement is also met by importing probiotics from other countries. The most commonly found commercial probiotic drinks for human consumption are found in the form of probiotic drinks, icecreams and frozen desserts. The latest and recent addition to the list of probiotics in India is ViBact (which is made up of genetically modified Bacillus mesentricus), which acts as an alternate to B-complex capsules (Sonal et al 2008). Probiotic products are gaining acceptance mostly in urban areas. The Indian market is big, but difficult to reach since cold storage and cold distribution chain are underdeveloped in India, especially in the rural areas. In the future, it is important to increase the awareness of the country people and to educate them about the probiotics' benefits.

Conclusion

The prospect for the Indian probiotic market is expanding at a rapid pace due to globalization and increase in health awareness amongst Indian population especially urban lower middle class and rural masses. Realizing this, the Indian dairy industry has undergone a paradigm shift from manufacturing traditional milk products towards more beneficial functional milk products such as probiotics, or yogurt. In this respect, the proactive support of the government alongwith the fundamental factors like uninterrupted supply of raw materials, qualified man power, congenial investment climate are paving the way for the probiotic industry to make giant strides in Indian market. Consumers should understand that anything in excess is not always good though probiotic has shown a lot of potential in aiding number of illness and conditions. In the past few decades, lot of research has been carried out in this direction but no concrete conclusion could be drawn till date and have to still wait more as research is going on in this direction. Till then, consumers should understand the concept, "probiotic rather than medicine". Besides this, in the existing situation, excellent growth opportunities are stored for both domestic as well as for foreign companies to venture their capital in the probiotic industry and to make a mark for the betterment of the society.

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