Review Article

Milk, milk products and disease free health: an updated overview

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ABSTRACT

The cow and its milk have been held sacred in India since the dawn of human civilization. Indian ancient Vedic texts also describe the virtues of milk and dairy products, as is authenticated by modern scientific principles and proofs. Therefore, milk has been considered as one of the most natural and highly nutritive part of a daily balanced diet. Currently, the integration of advanced scientific knowledge with traditional information is gaining incredible momentum towards developing concept of potential therapeutic foods. Furthermore, new advances towards understanding the therapeutic roles of milk and milk products has also given a new impetus for unraveling the old- age secrets of milk. At present, the best-known examples of therapeutic foods are fermented milk products containing health promoting probiotic bacteria. In present article, we have tried to review the various aspects of the therapeutic nature of milk and fermented dairy products in a highly up-dated manner, and offer an in-depth insight into the development of targeted therapeutic future foods; as per the admirable requirements of consumers.

Key words: Milk, dairy products, synbiotics, functional foods, therapeutic foods.

INTRODUCTION

Milk, our very first food, is surrounded with emotional, cultural and religious importance. We are habituated since childhood to think of milk as "nature's most perfect food". Milk and dairy products have long been acknowledged as an important constituent of a balanced diet. In addition, evidence of health benefits of milk products allied with the presence of specific components or bacteria are progressively gaining established scientific credibility. It is, therefore, logical that among the best-known examples of functional foods are fermented milks and yogurts containing probiotic bacteria (Weaver, 2003; Kurien et al, 2005). These days, the boundary line between food and medicine is also becoming diffused with the enhanced understanding of food science and technology. Among the various food products, milk has primarily been identified to have a high potential for health improvements for human beings. It is an optimally rich source of vital nutrients such as proteins, fat, lactose, vitamins, minerals, enzymes, hormones, immunoglobulins and cells. Dairy products are consumed not only for meeting the nutritional requirements of the consumers, but also for their role in preventing various disorders such as obesity, osteoporosis, dental caries, poor gastrointestinal health, cardiovascular diseases, hypertension, colorectal cancer, bone ailments, eye diseases, ageing etc. (Sharma and Rajput, 2006). Hence, we have made an attempt to highlight the various therapeutic aspects of milk and milk-based foods with special reference to their role in combating several life-style diseases and disorders, aside from some of the basic knowledge pertaining to this category of foods.

HISTORICAL PERSPECTIVE

Ancient Indian literature (Upnishads, Purans and Vedas) is full of evidences of the beneficial and therapeutic properties of milk and milk products. The Rigveda describes a cow as Amrutasya nabhih and compares ghee to nectar. Sadhays and Vasus, who tasted cow milk, became immortal, as is said in the Atharva Veda. The milk of Surabhi, which is considered the celestial cow and supreme among all bovines, is useful to humans, as mentioned in the Mahabharata. Milk, according to Bhava Prakasha, is a remedy for the patients of chronic diseases such as epilepsy, jaundice, heart ailments, suppression of stool and urine, spleen enlargement and piles. Bhava Prakasha states that Dadhi acts as an appetizer, tones up a weak person, and also work as an anti-tode against chronic diseases of kidney. Ayurveda emphasizes on the ability of milk to revitalize the energy system of the body. Buttermilk warmed with curry and/ or

coriander leaves, turmeric, ginger and salt is relished in Kerala (India), which, as per the ancient science, is the reason for least cases of obesity and indigestion being reported in that state (Sabikhi and Mathur, 2004). Milk, according to Ayurveda, is a laxative whereas dahi has the opposite effect of curing diarrhea.

Cow's milk was first used as human food in the Middle East. Goats and sheep were also domesticated in the Middle East between 9000 and 8000 BC. Around 7000 BC, cattle were being herded in parts of Turkey. There is evidence of milk consumption in the British Isles during the Neolithic period, and the use of cheese and butter spread in Europe, and parts of Asia and Africa. Domestic cows, which previously existed throughout much of Eurasia, were then introduced to the colonies of Europe during the 'Age of Exploration'. Russian Scientist Elie Metchnikoff was the first person to notice the beneficial effect of fermented milk products as probiotics (Greek; pro = for, bios = life) or therapeutics in his publication on 'Prolongation of Life, 1908'. He found that the colon housed the friendly bacteria similar those good bugs found naturally in fermented milk such as curd, yogurt, acidophilus milk, cultured buttermilk etc. called *Lactobacillus.*

MILK AND WELL BEING

The three most important factors that primarily contribute to health are diet, exercise and genetic factors. Milk is not only nature's food for a new born infant, but also a source for a whole range of dairy products consumed by mankind. Milk contains about 87% water and 13% solids. The fat portion of the milk contains fat-soluble vitamins. The solids (other than fat) include proteins, carbohydrate, water-soluble vitamins, and minerals. Milk products contain high quality proteins. The whey proteins constitute about 18% of the protein content of the milk. Casein, a protein found only in milk, contains all of the essential amino acids and accounts for 82 % of the total proteins in milk. Milk also contains calcium, phosphorus, magnesium, and potassium. The calcium found in milk is readily absorbed by the body; Vitamin D plays a role in promoting the calcium absorption and its utilization. Milk is also a significant source of riboflavin (vitamin B2), which helps promote healthy skin and eyes (Dairy Facts, 2003). Dairy products such as yogurts, cheeses and ice creams contain nutrients such as proteins, vitamins and minerals. Consumption of dairy products has been associated with decreased risk of osteoporosis, hypertension, colon cancer, obesity and insulin

resistance syndrome. The main dietary source of calcium and vitamin D are dairy products (Weaver, 2003).

Milk can be converted into a number of dairy products, and most of these products have already achieved a reputed health-oriented image in consumer's mind, and have proved to be an excellent solution for formulating superior nutrition (Table 1). Overall, dairy foods can be divided into three groups:

- Basic products i.e. milk, fermented milks, cheeses, ice-cream, etc.
- Value-added products, in which the milk composition has been changed, e.g. low-lactose or lactose-free products, hypoallergenic formulae with hydrolyzed protein for milk-hypersensitive infants, milk products enriched with Ca, vitamins, etc.
- Functional/ therapeutic dairy products, primarily those containing probiotic bacteria, and quite frequently enriched with prebiotic carbohydrates.

Since, many chronic diseases such as cancer, osteoporosis, coronary heart disease and hypertension are connected to an unbalanced diet; consumers have now started accepting that diet has a great influence on health and well-being. As a result of this, the food industry has taken benefit of new avenues for producing health oriented milk products. Food processing and biotechnology has enabled the food industry to make food with special characteristics. In addition to disease prevention, the role of food as an agent for improving health has been projected. Probiotics, prebiotics, synbiotics and functional foods have been created to describe food products with special characteristics. Developing functional value in dairy-based products simply means enriching the healthy nature of the original base. Functional foods are generally described as foods that promote health beyond providing basic nutrition. A food can be regarded as 'functional' if it satisfactorily demonstrates to affect beneficially one or more target functions in the body, beyond adequate nutritional effects in a way that is relevant to improved health or reduced risk of disease. These foods are eye-catching to modern men and women who wish to reach old age in a healthy form. The best known examples of functional food are fermented milks and yogurts containing probiotic bacteria (Nagpal *et al.*, 2007a).

Milk, our very first food, is surrounded with emotional and cultural importance. We have been habituated since childhood to think of milk as "nature's most perfect food. Now, we (almost all of us, infants, the young, adolescents, adults and even the aged)

are a nation of milk drinkers. We drink several hundred gallons of milk a year and add to that many pounds of dairy products such as cheese, butter and yogurt. Milk and dairy products have long been acknowledged as an important constituent of a balanced diet. These products provide a wide range of important nutrients. In addition, evidence of health benefits of milk allied with the presence of specific components or bacteria is progressively gaining established scientific credibility. It is therefore logical that among the best known examples of functional foods are fermented milks and yogurts containing probiotic bacteria. Milk itself is much more than the sum of its nutrients. It is a natural source of a jumble of beneficial nutrients and biologically-active compounds with a potential impact on human health. Further, probiotic microorganisms present in milk or fermented milk products, such as dahi, cheese etc., beneficially affect the host improving the properties of intestinal microbial balance. These probiotic effects include alleviation of intestinal disorders such as lactose intolerance, acute gastroenteritis due to enteric pathogens, constipation, inflammatory bowel disease, and food allergy. Three most important factors contributing to health are diet, exercise and genetic factors. There are only a few people who are familiar with terms like probiotics and functional food. The determinants of healthful effects of dairy product are multi-factorial, for example, live bacteria and other components of fermented milk such as highly absorbable calcium, conjugated products of linoleic acid (CLA) and bioactive peptides (Nagpal *et al.,* 2007b).

Coronary heart disease, the most common and severe form of cardiovascular disease, is the foremost cause of death in developed countries. Milk and dairy products contain components with at least a protective, if not hypocholesterolemic, effect such as calcium, linoleic acid, conjugated linoleic acid, antioxidants and lactic acid bacteria or probiotic bacteria. Calcium plays an important role in mediating vascular contraction and vasodilatation, muscle contraction, nerve transmission and glandular secretion. Linoleic acid is also favorable in reducing coronary heart disease risks in human subjects. Probiotics, in the form of fermented milk products, have the reputation of cholesterol-lowering properties in humans (Yadav *et al.,* 2006a, b; 2007a, b,c).

Hypertension is another modern day problem and again both genetic and environmental factors influence blood pressure. People with high blood pressure are at increased risk of coronary heart disease, stroke, and kidney failure. It is not only an excess of one electrolyte (sodium) in our diets but rather inadequate levels of several others that

produce hypertension. An adequate intake of calcium, potassium, and magnesium has now been documented to reduce blood pressure. It has already been proved that effect of milk on blood pressure is greater and more rapid than that of calcium alone. Milk and dairy products are meaningful sources of all three nutrients along with certain bioactive peptides with a potential to reduce blood pressure due to their ability to inhibit the formation of some potent vasoconstrictors (Ashar and Chand, 2004a).

Colorectal cancer is one of the leading causes of cancer morbidity and mortality in the Western countries and it is thought to be caused by an interaction between dietary factors and genetic predisposition. The components in dairy foods which may protect against colon cancer are above all calcium, vitamin D, probiotic lactic acid bacteria, a class of fatty acids known as conjugated derivatives of linoleic acid (LCA) and bioactive peptides derived from milk proteins. The high amounts of colloidal calcium phosphate in milk products cause intestinal formation of insoluble, amorphous calcium phosphate, which precipitates bile acids, fatty acids, and other unknown cytotoxic factors and thus inhibits colonic epithelial proliferation. The human colon is intensively colonized with bacteria and as such an extremely complex microbial ecosystem. The majority of these residents is in fact benign and may even offer some health-promoting effect. The lactic acid bacteria termed probiotics are the most prominent representatives of health promoting colon-residents. Oral administration of certain probiotic bacteria is associated with a number of anti-carcinogenic actions, including reduction of colonic pH, immuno-stimulation, anti-mutagenicity and reduction in the activity of enzymes responsible for the conversion of procarcinogens to carcinogens. Fermented milk products, specially those containing probiotic bacteria, may help reduce the risk of cancer at a number of sites. Milk proteins are most likely another milk component with anti-carcinogenic properties, and may therefore retard the development of colon tumors and tumor precursors. Besides, milk whey also contains different high-affinity binding proteins that bind iron, folic acid, vitamin B12, riboflavin, retinol and vitamin D. Their bioactivity is very important for keeping an organism in a healthy condition. Lactoferrin binds iron which is potentially pro-carcinogen and thus prevents intestinal damage, whereas the vitamin binding proteins protect vitamins from intestinal microflora (Daniel et al., 1990; Rokka et al., 1997).

Moreover, with an already healthy image, dairy is an excellent solution for formulating flavorful and nutritious functional beverages such as sport drinks, energy drinks and

smoothies. Dairy-based beverages provide superior nutrition, as dairy is a source of high quality proteins, calcium, potassium and other nutrients. Such protein-rich beverages provide not only with a source of high-quality protein, but also may add a variety of health benefits that make dairy proteins ideal for a variety of functional beverages. The fat in milk can also be a natural source of conjugated linoleic acid, which may offer health benefits. Dairy also provides an excellent vehicle for delivering probiotics, which play an important role in intestinal health, immunity and other health issues. In addition, ultra-filtered (UF) milk provides the opportunity to create unique dairy-based beverages, such as low-carb/ high-protein drinks. Dairy proteins, such as casein and whey, offer all of the essential amino acids the body requires. Higher daily intake of proteins and their components, especially the high amount of leucine found in dairy proteins, may help people lose fat while preserving lean muscle.

Dairy proteins contain several components that may help the human body protect itself against toxins, bacteria and viruses. For example, lactoferrin, an iron-binding whey protein, may increase iron absorption and transport, enhance immunity and stimulate growth of beneficial bacteria in the intestinal tract. Probiotics are a perfect fit for these dairy-based beverages, as dairy is an excellent vehicle to deliver beneficial bacteria such as Bifidobacterium and Lactobacillus species. Consumption of probiotics with dairy foods such as milk, yogurt and cheese buffers the stomach acid and increases the chance that the bacteria will survive into the intestine. The healthful properties of probiotics also work well with the healthful properties of dairy beverages. Probiotic cultures have been shown in a variety of test systems to stimulate certain cellular and antibody functions of the immune system. Lactic acid bacteria also enhance the levels of certain immuno-reactive cells (e.g. macrophages and lymphocytes) or factors (cytokines, immunoglobulins and interferon). Exposure to probiotics early in life may decrease the risk of allergy. Dairy products are the major natural sources of CLA which is naturally present in cow’s milk, holds anti-cancer properties, and have a positive impact on cardiovascular health (Nagpal *et al.,* 2007b). Calcium is not only essential for bone health; it has also been linked to the maintenance of healthy blood pressure and reduction of dental cavities. The resulting ultra-filtered (UF) milk, in both fluid and powdered forms, offers opportunities for lower-carb beverages. From proteins and probiotics to nine essential vitamins and minerals, dairy-based beverages have much to offer today’s health-conscious consumer.

HEALTH PROMOTING MILK FOODS

There is a growing trend of health awareness all over the world, wherein consumers and health professionals alike are increasingly adopting a preventive approach rather than a curative one to diseases. While antibiotic therapy is currently the most commonly used approach to treat bacterial infections, it is essentially curative and is associated with unpleasant side effects. Probiotics, on the other hand, score over antibiotics by being preventive, non-invasive and free from any undesirable effects.

Consequently, the awareness and popularity of probiotics among the global population is increasing rapidly (Sanders, 1998). Several health benefits have been attributed to the ingestion of probiotic bacteria such as *Lactobacillus* spp and *Bifidobacterium* spp. These bacteria enhance the population of beneficial bacteria in the human gut, suppress pathogens and build up resistance against intestinal diseases. Ingestion of these bacteria is considered to be very effective in preventing diarrhea in children and in alleviating symptoms of lactose intolerance in adults (Salminen *et al*., 1999; Goyal and Gandhi, 2006). Probiotic food products have also been called nutraceuticals, pharma-foods, designer foods, nutritional foods, medical foods or super foods (Childs and Poryzees, 1998).

Functional milk foods: foods with therapeutic values

Probiotic bacteria are live microbial strains that, when applied in adequate doses, beneficially affect the host by improving its intestinal microbial balance. Probiotic foods are products that contain a living ingredient in sufficient concentration, so that after their ingestion, the postulated effect is obtained (deVrese and Schrezenmeir, 2001). A good probiotic microorganism should meet the following criterion:

- Be easily produced at lab or home.
- Non-toxic and non-pathogenic to the host.
- Better adherence to the host intestine for positive and lasting results.
- Withstand at high acid in host’s stomach.
- Remain viable for a longer period of time.

Common probiotics include 1) lactobacilli such as *L. acidophilus, L. johnsonii, L. casei, L. delbrueckii ssp. bulgaricus, L. reuteri, L. brevis, L. cellobiosus, L. curvatus, L. fermentum, L. plantarum*; 2) gram positive cocci such as *Lactococcus lactis ssp.*

cremoris, Streptococcus salivarius ssp. thermophilus, Enterococcus faecium, S. diacetylactis, S. intermedius; and 3) bifidobacteria such as *B. bifidum, B. adolescentis, B. animalis, B. infantis, B. longum* (Mercenier et al., 2002). Also other microbial species, besides lactic acid bacteria (LAB) like *Bacillus subtilis*, *Propionibacterium* spp. and yeasts (*Saccharomyces boulardii*) have been accepted and used as probiotics (Jan et al., 2001).

The second generation of probiotics is genetically modified microorganisms (GMO) providing the host with some necessary components e.g. production of immuno-modulators (e.g. interleukins). Probiotic products may be conventional foods (yogurt, cheese, milk) consumed for nutritional purposes, but also for the probiotic effect; food supplement/ fermented milks or medicinal foods; dietary supplements: capsules, tablets, liquids, powder (Ross, 2000; Temmerman et al., 2002). Probiotic preparations used as food supplement can consists of one single strain (e.g. yakult, Japan – *L. casei* Sirota) or there are mixed cultures of two (e.g. Bacilac, Belgium – *L. acidophilus* plus *L. rhamnosus*) or even more (e.g. food supplement VSL-3, Italy, contains 8 LAB species) strains.

Historically, humans were exposed to probiotics through fermented foods. The modern diet however contains dramatically decreased numbers of fermented foods. Moreover, the increased hygiene measures in food manufacturing plants and restaurants have resulted in human beings exposed to as few as one millionth of the probiotic organisms to which their ancestors were exposed (Markowitz and Bengmark, 2002). Ageing, increased stress and a hectic lifestyle have further contributed to the declining populations of probiotic organisms in the human gut (Lourens-Hattingh and Viljoen, 2001).

In the current situation, it becomes critical to supplement human diet with adequate doses of probiotic microorganisms to re-establish the intestinal microflora balance and help maintain good health. Consequently, in recent times, probiotics have been marketed as dietary supplements in the form of tablets, capsules and freeze-dried preparations (Shah, 2000). Probiotic cultures can be more effective, when ingested in a food medium. An empty stomach has a low pH that destroys most bacteria. When food is ingested, the pH in the stomach quickly rises and probiotic bacteria can easily pass unharmed to the small intestine where they are most effective (German et al., 1999).

In addition to directly introducing live probiotics to the colon through dietary supplementation, another approach to increase the numbers of beneficial bacteria in the intestine is using prebiotics (Kurien et al, 2005; Mandal et al, 2006). Prebiotics are defined as non-digestible food ingredients that beneficially affect the host by selectively stimulating the growth of beneficial bacteria in the colon, and thus improve host health (Gibson and Roberfroid, 1995). The prebiotics identified are non-digestible carbohydrates that supply a source of fermentable sugar for beneficial bacteria only in the colon (Crittenden, 1999).

An approach that combines both probiotics and prebiotics is called *synbiotics* (Ligi et al, 2006). Synbiotics is defined as a mixture of probiotics and prebiotics that beneficially affects the host by improving the survival and implantation of live microbial dietary supplements in the gastrointestinal tract, by selectively stimulating the growth of a limited number of health-promoting bacteria, and thus improving host welfare (Gibson and Roberfroid, 1995). In contrast to probiotics, which introduce exogenous bacteria into the human intestine, prebiotics stimulate the preferential growth of a limited number of bacteria already existing in a healthy, indigenous microbiota. The main dairy products enriched with prebiotics are yoghurts and yoghurt drinks, but spreads, fresh cheeses and milks are also on the market.

Conventionally, food healthiness has been associated with nutritional factors such as fat, fibre, salt and vitamin content. In addition to this traditional healthiness, food may contain single components that may have a positive impact on our well-being. Products that are claimed to have special beneficial physiological effects in the body have been called nutraceuticals, pharma foods, designer foods, nutritional foods, medical foods, therapeutic foods or super foods (Childs and Poryzees, 1998). More usually they are termed *functional foods*. The first functional food products were launched in Japan where a food category called FOSHU (Foods for Specific Health Use) was established in 1991 to reduce the increasing health-care costs. The first functional probiotic fermented milk drink ‘Yakult’ has been available in Japan already since 1935 (Karimi and Pena, 2003).

According to a concerted action project FUFOSE (Functional Food Science in Europe) coordinated by ILSI (International Life Sciences Institute), "a food can be regarded as functional if it has been satisfactorily demonstrated to affect beneficially one or more target functions in the body beyond adequate nutritional effects in a way that is relevant

to either an improved state of health and well-being and/or a reduction of risk of disease" (ILSI Europe, 2002). Besides providing scientifically proven health effects, functional foods have to maintain a food-like nature and they have to be easily incorporated into the daily diet. A functional food must remain food and it must demonstrate its effects in amounts that can normally be expected to be consumed in the diet: it is not a pill or a capsule, but it is a part of the normal food pattern" (Diplock et al., 1999).

It is now well established that there is a clear relation between diet and health. More recent discoveries support the hypothesis that, beyond nutrition, diet may modulate various functions in the body. Functional foods are gaining more widespread popularity and acceptance throughout the developed world and are already well accepted in countries like Japan and the United States. Functional foods can include probiotics, prebiotics and synbiotics (DiRienzo, 2000). The concept of probiotics evolved from a theory first proposed by Nobel Prize winning Russian scientist, Elie Metchnikoff who suggested that the long life of Bulgarian peasants resulted from their consumption of fermented milk products. Probiotic bacteria can be found worldwide in a variety of products, including conventional food products, dietary supplements and medical foods. The main outlets for probiotic bacteria are dairy foods and dietary supplements and medical foods. Dairy foods containing probiotic bacteria include most major brands of yogurt, culture containing fluid milks, such as sweet acidophilus milk and a few brands of cottage cheese. Dairy foods seem to fit naturally with probiotics because of the traditional association of beneficial fermentation bacteria and fermented dairy product. Consumers naturally associate fermented dairy products with live cultures and perceive a benefit in the presence of these cultures (Sanders, 2000).

The concept of functional foods seems to be attractive and consumers have accepted such health-tailored food products. For instance, in 1998, Childs and Poryzees (1998) reported that 42% of Americans were interested in regularly buying foods that could help prevent disease. Functional food is intended for a population generally in normal health and must demonstrate beneficial effects in amounts that are usually consumed in the diet. Functional food is a natural food, to which a component has been added/ removed or a food in which the bioavailability of the components has been modified by technological or biotechnological means (Korhonen, 2002). Functional foods can be classified into different groups according to their effects: probiotics, prebiotics and

dietary fibers, antioxidants, vitamins, polyphenols, plant sterols, poly-unsaturated fatty acids and minerals. The most promising targets for functional foods are the GI functions and particularly control of nutrient bioavailability (Roberfroid, 2000). However, functional foods can affect different systems in the body, e.g. balanced colonic microflora, control of transit time and mucosal motility, bowel habits; modulation of epithelial cell proliferation, balance of redox and antioxidant systems, metabolism of macronutrients, esp. amino acids, carbohydrates and fatty acids.

Functional symbiotic foods

Historically, humans were exposed to probiotics through fermented foods. The modern diet however contains dramatically decreased numbers of fermented foods. Moreover the increased hygiene measures in food manufacturing plants and restaurants have resulted in humans being exposed to as few as one millionth of the probiotic organisms to which their ancestors were exposed (Markowitz and Bengmark, 2002). Ageing, increased stress and a hectic lifestyle have further contributed to the declining populations of probiotic organisms such as lactobacilli and bifidobacteria in the human gut (Lourens-Hattingh and Viljoen, 2001). In the current situation, it becomes critical to supplement human diet with adequate doses of probiotic microorganisms to re-establish the intestinal microflora balance and help maintain good health. Consequently, in recent times, probiotics have been marketed as dietary supplements in the form of tablets, capsules and freeze-dried preparations (Shah, 2000). Some of the commercial probiotic products available in the market are shown in Table 1.

Probiotic cultures can be more effective however, when ingested in a food medium. An empty stomach has a low pH that destroys most bacteria, except those lactic acid bacteria that adhere to the stomach mucosa. When food is ingested, the pH in the stomach quickly rises and probiotic bacteria can easily pass mostly unharmed to the small intestine where they are most effective. Such foods incorporated with probiotic cultures fall under the category of functional foods which are broadly defined as ‘foods similar in appearance to conventional foods that are consumed as part of a normal diet and have demonstrated physiological benefits and/or reduce the risk of chronic disease beyond basic nutritional functions’ (German et al., 1999). In addition to directly introducing live bacteria to the colon through dietary supplementation, another approach to increase the numbers of beneficial bacteria such as bifidobacteria in the intestinal microbiota is using prebiotics, in the form of synbiotic foods.

MAJOR THERAPEUTIC ATTRIBUTES OF MILK FOODS

In this section, we have described various health benefiting roles of functional dairy foods:

Lactose intolerance

Lactose, a type of sugar that naturally occurs in milk is hydrolyzed by lactase enzyme developed in the small intestine. Some people are not able to produce enough lactase so undigested lactose is broken up by the bacteria in the large intestine causing gas, bloating, pain and diarrhea. This condition is called 'lactose intolerance' and is quite common in most parts of the world. One can be born lactose intolerant or develop it later in life (Heyman, 2006).

There is convincing evidence from several studies that symptoms of lactose-intolerance are reduced with the consumption of probiotic dairy products (Fonden et al, 2000; Salminen and Gueimonde, 2004). The mechanism of action of probiotic bacteria and fermented products includes lowering of lactose concentration in the product that could result in high lactase activity and thereby increasing the active lactase enzyme entering the small intestine. The bacterial enzyme, beta-galactosidase found in the ileum after consumption of fermented milk products with viable probiotic bacteria is the major factor that improves digestibility by lactose hydrolysis (de Vrese et al., 2001; Saltzman et al., 1999; Vesa et al., 2000; Vinderola and Reinheimer, 2003). This is true for all fermented dairy products, especially yoghurt/ dahi, owing to the enzyme activity of the culture and the higher consistency of fermented milks compared with ordinary milk. Milk and milk products are highly nutritious, so people who suffer from lactose intolerance should not give them up entirely. One can still consume milk in moderate quantities i.e. half a cup of milk, three quarters of a cup of ice-cream or yoghurt etc. Milk foods that contain lactose are better tolerated, if eaten with other foods containing probiotic bacteria or spread out over the day, rather than being eaten in large amounts at once (Talhouk et al, 1996; Salminen et al, 1999).

Hypertension

According to the Vedic literature, milk also helps in relieving mental tension. Milk also suppresses pain during abortion, childbirth and at times of extreme fatigue. Hypertension, a modern day's problem is influenced by genetic and environmental factors. People with high blood pressure are at increased risk of cardiovascular disease

and stroke. It is not only an excess of one electrolyte (sodium) in our diets but also rather inadequate levels of several others that produce hypertension. An adequate intake of calcium, potassium, and magnesium has now been documented to reduce blood pressure. It has already been proved that effect of milk on blood pressure is greater and more rapid than that of calcium alone. Milk and dairy products are meaningful sources of all three nutrients along with certain bioactive peptides with a potential to reduce blood pressure. Main components of milk products with anti-hypertensive activity include: calcium, peptides derived from whey proteins, casein phosphopeptides, fermented dairy products (Patel and Renz-Schanen, 1998; Marshall, 2004; Ashar and Chand, 2004a, b).

Heart diseases

According to the Puran, consumption of milk with Nagara roots, Suvarcala salt and Sivaghrta was a remedy for all heart ailments. It was also reported that milk cooked with dried pippali and consumed with honey, sugar and ghee cured cough and chronic heart diseases. Milk and dairy products contain components with at least a protective, if not hypocholesterolemic, effect such as calcium, conjugated linoleic acid, antioxidants and probiotic bacteria. Linoleic acid is also favorable in reducing coronary heart disease risks in humans. Probiotics, in the form of fermented milk products, have the reputation of cholesterol-lowering properties in humans. Some bacteria harbor enzymes that are capable of utilizing cholesterol (Gilliland et al., 1984; James at el, 1999; Xiao et al, 2003).

Overweight

Due to lack of knowledge, a lot of people, who are trying to lose weight, avoid milk and other dairy foods. However, it is well known that dairy foods in a low-calorie diet may actually help with managing the body weight. A number of studies have shown that a low-calorie diet, rich in dairy nutrients, may actually change the way fat cells work, reducing the amount of body fat stored, particularly from around the abdominal (waist) region. Weight loss from around the abdomen is beneficial for reducing the risk of heart disease and type-2 diabetes. Maintaining a healthy body weight means burning off at least as many calories as you eat. If you need to watch your weight, then choose reduced fat and low fat dairy products for fewer calories (Zemel, 2005).

Dentist milk foods

Teeth and bones are very alike. So the calcium, phosphorus and protein found naturally in dairy foods are just as important for building and maintaining strong healthy, teeth as they are for your bones (Patel and Renz-Schanen, 1998; Bowen, 2002; Johansson, 2002). Dairy foods are beneficial for your teeth in a number of ways:

- Calcium, phosphorus and protein can help build and maintain strong, healthy teeth.
- Milk is a tooth friendly drink, safe for in between meals, as it does not promote dental caries.
- The nutrients in milk and dairy can reduce the build up of acid on your teeth which occurs after eating sugary foods
- The combination of casein, phosphorus and calcium in cheese may actually help remineralize teeth and help reduce your risk of tooth caries.
- Stimulated saliva flow that is beneficial in a number of ways
- The dentists' recommends eating a small amount of cheese after meals as it may reduce your risk of dental caries.

Diabetes management

People, who have a high low-fat milk food intake, have a lower risk of type-2 diabetes mellitus; hence, diet and lifestyle modifications can substantially reduce the risk of type-2 diabetes. While a strong inverse association has been reported between milk food consumption and the insulin resistance syndrome among young obese adults, the relation between milk food intake and type-2 diabetes is yet to be completely understood. Dairy products i.e. dahi may produce an anorexic or insulinotropic effect and hence, reduces the risk of diabetes (Hyon et al, 2005; Yadav et al, 2006b).

Disease resistance

Some of the probiotic dairy products have been shown to enhance immune functions and thus to reduce the risk of infection in consumers. Milk and colostrums contains some natural immunoglobulins which reduce the risk of many infections in the host by preventing the occurrence of infections by microbes (Haque and Chand, 2006).

Sleeping sickness

Melatonin is a hormone that controls the body's day and night rhythm. The secretion of melatonin is high in early childhood and decreases rapidly with ageing. Stress conditions and age causes lowering of the level of melatonin. It is secreted at nights in both humans and bovines. The concentration of melatonin in cows' milk at night is about four times higher than in milk collected during the day. The level of melatonin in the milk complements that of the human body, and hence, the drink helps in having a relaxed sleep if taken at night or late in the evening, without causing any drowsiness the following morning (Irina et al, 1999; Valtonen et al, 2005).

Against bad bugs

Acute diarrhea is a serious cause of infant death. Bhava Prakash commends the antimicrobial properties of milk and its usefulness in controlling gastrointestinal disorders such as diarrhea and dysentery. The factors responsible for antimicrobial properties of milk are:

- Immunoglobulins: are present in high levels in colostrums. These can detoxify toxins, fight viruses, inhibit entero-pathogenic adherence to intestinal wall, prevent the absorption of food antigens, suppresses the growth of pathogens and aid in phagocytosis (Walzem, 2001).
- Lactoferrin: a whey protein present in bovine milk, strongly bind to iron, making it unavailable to entero-phathogenic bacteria (Reiter, 1985; Marshall, 2004)
- Lysozyme: present in bovine milk, degrades the bacterial cell wall of invading pathogens.
- Lactoperoxidase: interact with hydrogen peroxide produced by microbial growth, producing certain intermediary compounds that eventually lyse the pathogenic bacterial cell wall (Ballongue, 1998).

Cancer

Epidemiological studies indicate that humans who consume milk are less likely to develop cancer of the colon and the rectum. Conjugated linoleic acid is a natural component in milk fat and it may reduce the risk of certain diseases, such as breast cancer. The amount of conjugated linoleic acid in milk is higher in whole milk than in reduced or low fat milk. Yogurt consumption has been associated with a reduced incidence of colon cancer in some population groups, which was associated with peptides formed during fermentation (Ganjam et al, 1997).

Colorectal cancer is one of the leading causes of cancer morbidity and mortality and it is thought to be caused by an interaction between dietary factors and genetic predisposition. The components in dairy foods, which may protect against colon cancer, are above all calcium, vitamin D, probiotic lactic acid bacteria, a class of fatty acids known as conjugated derivatives of linoleic acid and bioactive peptides derived from milk proteins (Marshall, 2004; Rehmeyer, 2006).

Bone ailments

Calcium is widely recognized as very important ingredient for proper bone health. The consumption of milk and dairy products has been recommended since ancient times for strong bones. In addition to being a rich source of calcium, whey protein contains an active fraction that stimulates the proliferation of bone forming cells (Patel and Renz-Schanen, 1998; Whiting and Lemke 1999; Heaney, 2000). Dairy foods, which are rich in biologically available calcium, have long been shown to retard and minimize osteoporosis. We need calcium everyday because bones are continually being repaired and renewed (that's how broken bones mend!).

Youthful foods

Vasistha the ancient saint, retained perpetual youth for over thousand years by consuming milk and milk products obtained from divine cow Nandini, as mentioned in the Mahabharata. Milk products contain adequate amounts of essential nutrients that help in maintaining normalcy in health and general well being. Halawa prepared from whole- wheat flour and ghee is fed postpartum to ladies to overcome weight loss, to prepare the body for the additional requirement of feeding the child and tone-up the internal organs affected by pregnancy and childbirth (Grover and Dalal, 1993).

Eye-ailments

Milk incorporated with small amount of triphala paste acts as an excellent cure for several eye diseases if applied regularly into the eyes. Bhava Prakash states that freshly churned Makkhan is an excellent lubricant for eyes. Regular application of a few drops of fresh cow ghee in eyes is useful in preventing eye ailments according to the Ayurveda and also for exercising the eye muscles, as is practiced in traditional dance form Kathakali. Bovine milk particularly colostrums has high levels of vitamin A activity that initiates vision from light energy, and is essential for growth and in maintaining the epithelial tissue of eye. Cataract is a major cause of blindness in the

elderly. Recent epidemiological evidences suggest that eating of yogurt leads to dose-related protective effects against cataract (Salmon, 1994).

Suppress appetite

The soluble fraction remaining in whey after rennet coagulation of milk can suppress appetite by stimulation of the pancreatic hormones, which stimulates the gall bladder contraction and bowel mobility and regulates gastric emptying optimally (Walzem, 2001). Hence, this can avoid excessive and frequent dietary intake that ultimately leads to several complicated disorders.

Delaying of AIDS

During the past several years there have been several reports that whey proteins can be beneficial to patients with HIV infections. Supplementation with whey proteins increases plasma glutathione in advanced HIV infections that lead to better tolerance of the treatment. During a two weeks trial, the commercial source of protein did influence the extent of increase in plasma glutathione levels (Micke et al., 2001, 2002). Whey protein also has been shown to improve muscle strength in women with HIV (Agin, et al., 2001). Lactoferrin has also been shown to be inhibitory to HIV virus (Berkhout, et al., 2003). Ng et al. (2001) evaluated a number of bovine milk proteins for activity against HIV-1 enzymes which are considered to be important for the life cycles of the HIV virus.

Rotavirus diarrhea

Several studies have shown selected probiotics such as *L. reuteri, L. casei* Shirota, *B. lactis* Bb12 and *L. delbrueckii* ssp. *bulgaricus* can shorten the duration of rotavirus diarrhea by approximately one day (Boudra et al., 2001; Chandra, 2002; Kaila et al., 1992; Saavedra et al., 1994; Shornikovacasas et al., 1997; Sugita and Togawa, 1994). Shortening of the duration of rotavirus diarrhea using the probiotic strain *L. rhamnosus* GG is perhaps the best documented probiotic effect. It has been well documented in several studies around the world and in a recent multicenter study in Europe (Guandalini et al., 2000). *L. acidophilus*, has also been documented to shorten the duration of rotavirus diarrhea (Simakachorn et al., 2000). The mechanism behind this favourable outcome is associated with enhancement of IgA to rotavirus and serum IgA antibody level at convalescence. It is therefore suggested that certain strains of probiotic bacteria promote systematic and local immune response to rotavirus, which

may be of importance for protective immunity against re-infections (DeRoos and Katan, 2000; Fonden et al., 2000; McFarland, 2000).

Antibiotic-associated diarrhea

L. rhamnosus GG, *L. acidophilus*, *B. longum* and *B. animalis* have been reported to prevent antibiotic-associated diarrhea when consumed either in yogurt form or as a freeze-dried product (Arvola et al., 1999; Colombel et al., 1987; McFarland, 1998, 2000; Siitonen et al., 1990; Thomas et al., 2001; Vanderhoof et al., 1999; Witsell et al., 1995). These effects are mainly documented in infants; however, in case of adults, the data is not yet clear (Salminen and Gueimonde, 2004).

Allergy prevention and alleviation

The prevalence of allergic diseases has been on rise in the past few decades and is likely to continue to do so. It has been found that differences in intestinal microbiota composition precede the development of some allergic diseases (Bjorksten et al., 2001; Kalliomaki et al., 2001). This therefore indicates potential application of probiotic bacteria in this area. Administration of *L. rhamnosus* GG and *B. lactis* Bb12 prenatally to mother and during the first few months to infants with high risk of atopic disease reduced the prevalence of topic eczema (HelinHaatela et al., 2002; Kalliomaki et al., 2003; Majama and Isolauri, 1997). Additionally, supplementation of extensively hydrolyzed whey with *L. rhamnosus* GG or *B. lactis* Bb12, has been found to be more effective than unsupplemented formula on eczema alleviation in infants with atopic eczema (Isolauri et al., 2000).

BIOACTIVE PEPTIDES FROM MILK

Milk is well known to contain an array of bioactivities, which extends the range of influence of mother over young beyond nutrition alone. Most of the bioactivities of milk are attributable to the proteins and peptides secreted into milk by mammary gland. Many milk borne bioactivities are latent and require proteolytic release of bioactive peptides from inactive native milk proteins. However, some are natural and do not require digestion which otherwise destroy their bioactivities. Bioactive peptides have been identified as decomposition products of several food proteins (Brantl et al., 1979; Zioudrou et al., 1979; Loukas et al., 1983). Milk proteins are the most important sources of bioactive peptides. These have been shown to have various activities including opiate, antithrombotic or antihypertensive activity, immunomodulating or

mineral utilization properties. Some of them have been known to influence in insulin secretion or the motility and secretion of the intestine (Daniel et al., 1990). Bioactive peptides may be generated from milk protein *in-vivo* through gastrointestinal processes. Often, this liberation serves to influence numerous physiological responses as a result of their hormone like properties. These peptides encoded within the sequences of native protein precursors may also be generated *in-vitro* by enzymatic hydrolysis, such peptides from protein hydrolysates could be purified by various separation techniques. The physiologically active peptides have been chemically synthesized to confirm the biological properties associated with a specific amino acid sequence. There is considerable evidence that many bioactive peptides serve in multifunctional capacities and influence numerous biological processes evoking behavioral, gastro intestinal, hormonal, immunological, neurological and nutritional responses. The specific bio-reactions associated with each physiological class have been well characterized.

The major bioactivities of milk are summarized into four categories (based on their biological roles) as shown below:

a) Having gastrointestinal developmental activity and function:

i) Break down product of casein – casomorphins, casokinnins (ACE-I)

ii) Lactoferrin

iii) Growth factors IGE_1, TGF, EGF etc.

b) Having role in infant development:

i) Milk peptides

ii) Prolactin

iii) Growth factors

iv) Prosuposin

c) Having immunological functions:

i) Immunoglobulin IgG and IgA

ii) Cytokinins

iii) Prolactin

iv) Lactoferrin

v) Caseins – casomorphs and casokinins

d) Having microbiotic activity:

i) Antibiotic: Immunoglobulins, Lactoferrin, Glycolipids and Oligosaccharides

ii) Probiotic: Lactoferrin, k-casein glycomacropeptide and oligosaccharides

Depending upon their physiological functions, the bioactive peptides have been categorized as below:

- Antihypertensive
- Antimicrobial
- Antithrombic
- Mineral Binding
- Opioid

Although bioactive peptides do exist in a number of processed and fermented foods, their true physiological functions in humans are unknown. In healthy individuals eating a varied diet, the presence of bioactive peptides may help in keeping the nervous, immune and digestive systems in a well-maintained state. The future potential value of bioactive peptides in the diet may be their ability to affect certain pathological conditions, although this has yet to be proven. Casein derived peptides have already found interesting applications as dietary supplements (phosphopeptides) and as pharmaceutical preparations (phosphopeptides, casomorphins) (Brule et al., 1982, Reynolds, 1994). The efficacy and safe conditions of use of these peptides in animals and in humans remain to be proven. At present, ACE-inhibitory peptides and phosphopeptides are an important area in which bioactive peptides may be found to be useful ingredients for dietary applications. Peptides have also been shown to exert beneficial physiological effects (Table 2). These milk peptides may be considered as food additives and perhaps as starting components for development of some drugs. Casein derived peptides have already found interesting applications as dietary supplements and pharmaceutical preparations. Today, some of the biologically active peptides are known to be released during the *in-vivo* digestion, however, their

physiological function are not clearly understood, and hence, more research is needed to fully understand the functional significance of these substances.

FUTURE PROSPECTS AND CONCLUSIONS

The three most important factors contributing to health are diet, exercise and genetic factors. People conventionally think that food is food and medicine is medicine with no overlap between the two. At the end of the 1980s and particularly during the 1990s, interest in the area of relation between milk, milk products and health was generated and has increased significantly. Nowadays, such products are termed functional, i.e. foods that have an effect on health beyond their nutritional value. Their development has aroused immense interest and today, there are hundreds of foods in the market that, in addition to nutrition, also have health-maintaining or even therapeutic effects. The efficacy of the active ingredient used in a functional food or of a product that contains it has to be demonstrated in humans. There has to be a sufficient quantity of the active ingredient in the food. However, only a small fragment of global population is familiar with terms like probiotics and functional food. Probiotics are perfect fit for these dairy-based beverages, as dairy is an excellent vehicle to deliver beneficial bacteria such as *Bifidobacterium* and *Lactobacillus* species. Consumption of probiotics with dairy foods such as milk, yogurt and cheese buffers the stomach acid and increases the chance that the bacteria will survive into the intestine. The healthful properties of probiotics also work well with the healthful properties of dairy beverages. Probiotic cultures have been shown in a variety of test systems to stimulate certain cellular and antibody functions of the immune system. Exposure to probiotics early in life may decrease the risk of allergy. However, more rigorous research is required before such claims gain improved scientific credibility.

Milk is a rich source of nutritive compounds that can be enriched and/or further modified to give the best benefit to the consumers. However, in developing therapeutic dairy products, various groups of medical experts, nutritionists and microbiologists are considered important for their association. Food technologists are looked-for product development technologists and biotechnologists for processing the compounds, chemists to analyze these and, finally, the experts for marketing the products. It is important to remember that therapeutic dairy products are mainly for supplying nutritive foods for everyday consumption. Hence, nutria-marketing is also preferred to

explain research results to healthcare professionals and consumers so as to convince them of the benefits of therapeutic milk foods.

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923 **Table 1. Some commercial health-promoting probiotic products (Nagpal et al.,**
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Product	**Probiotic**
Muller Vitality Probiotic Yoghurt, UK.	*L. acidophilus* and *Bifidobacterium* sp.
Crunch n Yogurt™, General Mills, USA	*L.* acidophilus, *L. bulgaricus* and *Streptococcus thermophilus*
Classic flavor, France	*L. acidophilus*
Lactinex powder, Hyson, Westcott and Dunning	*L. acidophilus* and *L. bulgaricus*
LGG capsules, Japan	*L. rhamnosus* GG
LGG Milk, Japan	*L. rhamnosus* GG
LGG+, Iceland and Greenland	*L. rhamnosus* GG
Dukat BioAktiv Dairy Product, Slovenia	*L. rhamnosus* GG
Tnuva LGG1, Israel	*L. rhamnosus* GG
Beautiful Day LGG, Taiwan	*L. rhamnosus* GG
Culturelle capsules, USA	*L. rhamnosus* GG
Yakult, Japan	*L. casei*
Bacilac, Belgium	*L. acidophilus* plus *L. rhamnosus*
VSL-3, Italy	8 LAB species
Vitacel® prolac, Rosenberg	*Lactobacillus reuteri*
Amul Prolife probiotic ice-cream, India	*L. cremoris, L. lactis, L. bulgaricus and L. acidophilus*
Probiotic Dahi (yoghurt), NDRI, Karnal, India	*L. acidophilus* and *L. casei*
Symbalance yogurt, Switzerland	*L. reuterii*, *L. acidophilus* and *L. casei*

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927 **Table 2. Bioactive peptides identified in various fermented milk products.**

Product	Bioactivity	Reference
Fermented milks		
Sour milk	Phosphopeptides	Kahala et al., 1993
Sour milk	ACE-inhibitory	Nakamura et al., 1995
Sour milk	β-casomorphin-4	Matar et al., 1996; 2003
Fermented milk (Treated with pepsin and trypsin)	ACE-inhibitory Immunomodulatory Opioid	Rokka et al., 1997
Yoghurt	ACE-inhibitory (weak), Immunomodulatory, Antihypertensive, Antiamnesic, Microbicidal, Antithrombotic	Meisel et al., 1997
Cheeses		
Parmesan and Reggiano	β-casomorphin precursors	Addeo et al., 1992
Cheddar	Phosphopeptides	Singh et al., 1997
Edam, Emmental, Gouda	ACE-inhibitory	Meisel et al., 1997
Mozzerella, Italico, Crescenza	ACE-inhibitory	Smacchi and Gobbetti, 1998
Edam, Emmental, Turunmaa	ACE-inhibitory	Ryhanen et al, 2001
Cheddar, Edam, Swiss, Feta	Antihypertensive Anti amnesic Opioid	Dionysius et al., 2000

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