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Potential Functional Properties of Fermented Milk Beverages

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Abstract

Fermented milk beverages are manufactured by addition of starter culture (lactic acid bacteria) to carryout fermentation. Several changes with respect to the composition and physico- chemical properties take place in the fermented milk beverages. The metabolites formed as a result of fermentation exhibit functional properties and several health benefits. The components of the fermented milk beverages like lactose, protein, fat and starter culture possess functional properties. The prominent functional properties exhibited by the fermented milk beverages are prevention of gastro- intestinal disorders, anti- microbial property, anti- virulence, anti- allergenic characteristic, anti- tumor property, alleviation of lactose intolerance, decrease in serum cholesterol and food fortification vehicle. Hence, consumption of fermented milk beverages contributes to beneficial health and functional properties.

Keywords

Fermented Milk Beverages, Functional Properties, Anti- Viral Property, Anti- Tumor Property, Starter Culture.

INTRODUCTION

Milk is the lacteal secretion of mammals. Milk of cattle especially cow, buffalo and sheep are commercially important and are rich source of various nutrients. It is considered as complete food as milk contains most of the essential nutrients like carbohydrates, protein, fats, vitamins and minerals in adequate concentrations. However, the bio-availability of the nutrients can be enhanced by subjecting milk to various processes like fermentation, heat treatment, concentration, *etc.*, among which fermentation is the most efficient method. Fermentation is the method of conversion of sugar or carbohydrate to acids, alcohols and flavor compounds by specific microorganisms under controlled conditions. Yogurt, *dahi*, *lassi*, cheese, butter milk, probiotic milk, *kefir*, *kaumiss*, acidophilus milk, *bifidus* milk, *etc.*, are some of the products formed by fermentation of milk. Beverages are consumed worldwide to quench thirst, easy to consume, provide hydration to body with supply of desired nutrients, helps to maintain hydration balance in the body. Fermented milk beverages are the liquid fermented milk products. They possess several functional properties and health benefits. The functional properties of food products are the resulting factors due to physical and chemical changes that occur during food processing and preservation. The functional properties include, hydration, gelation and aggregation, interfacial and sensorial properties which depends on physical state, chemical property, molecular size, structural diversity, thermal property and processing treatments [1].

FERMENTED MILK BEVERAGES

Milk is added with suitable starter culture that carryout fermentation process to produce fermented milk. The fermented milk beverages are prepared by addition of desired quantity of water or skim milk or whey and optional ingredients like sugar, salt, spices with desired flavors.

Fermentation of milk lead to conversion of lactose to lactic acid which reduces the pH due to increase in acidity. The reduction in pH leads to destabilization of protein thus, coagulation of protein takes place. Fat and minerals are not extensively affected. During fermentation, there will be exponential growth of starter culture which produces metabolites that acts as flavor compounds (diacetyl, acetaldehyde, alcohol), antimicrobial compounds (nicin, bactericin) [2].

The fermented milk beverages which are commercially and economically important are yogurt drink, yogurt shake, *lassi*, *chaas*, *kefir*, *koumiss*, probiotic milk, acidophilus milk *etc.*, (Figure 1).

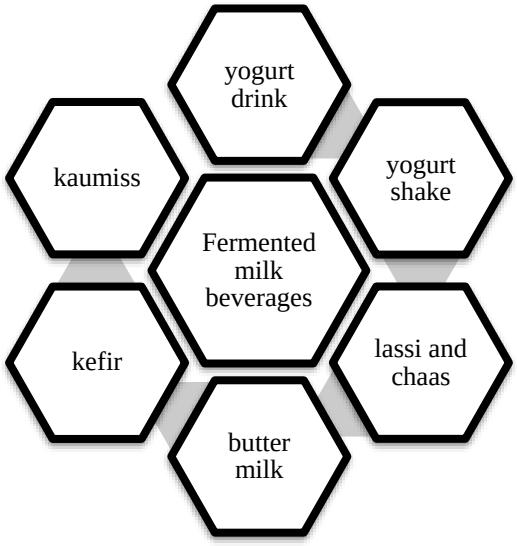

Figure 1. Fermented milk beverages

FUNCTIONAL COMPONENTS OF FERMENTED MILK BEVERAGES

The functional characteristics of fermented milk beverages are attributed to the different components present in milk as well as starter culture used for fermentation and the metabolites produced by the starter culture after fermentation. The major functional components that exhibit functional properties are lactose, protein, fat, lactic acid bacteria (LAB).

Lactose

Lactose is the disaccharide present in the milk also called as milk sugar. During fermentation lactose is converted into lactic acid by lactic acid bacteria (LAB). The pH of the medium is reduced due to production of acid which influences the physical, rheological characteristics of casein, enhances digestibility, absorption of calcium, phosphorous and inhibits the proliferation of pathogens and other harmful bacteria. Fermented milk can be consumed by lactose intolerant individuals due to reduced lactose content as compared to unfermented milk [2].

Proteins

The LAB brings about many changes during fermentation, the proteolytic activity of LAB leads to denaturation of proteins and production of peptides and amino acids. Certain peptides and amino acids possess bioactivity which acts as functional food and are used as nutraceuticals. The bioactive peptides like casomorphins, casokinins, immunopeptides, lactoferrin, lactoferricin and phosphopeptides are produced as a result of proteolysis. The milk protein derived bioactive peptides are inactive in the parent protein and possess activity after enzymatic proteolysis or gastrointestinal digestion. The key biological properties of peptides are anti-microbial activity, immunomodulation, antithrombotic property, blood pressure regulation, and mineral or vitamin adsorption [3]. Fermented milk also possesses several whey proteins like α-lactalbumin, β- lactoglobulin, lactoferrin, lactoperoxidase and immunoglobulins. They are reported to exhibit anti-carcinogenic and several digestive functions [4].

Fat

Fermentation helps in increasing the digestibility and assimilation of fat during fermentation. Milk fat consists of saturated as well as unsaturated fats. It also contains, conjugated linoleic acid (CLA), sphingomyelin, butyric acid, ether lipids, β- carotene, Vitamin A and Vitamin D that possess anti- carcinogenic activity, aids in prevention cardio-vascular diseases and immunomodulation [5].

Probiotics and prebiotics

Probiotics are the live microorganisms which possess beneficial effect on the host by enhancing the intestinal microbial balance. While, prebiotics are non- digestible components which exhibit beneficial effect on the host by selective stimulation of specific microorganisms. The gastrointestinal tract of human possesses extremely complex microbial ecosystem which influence various physiological properties. Probiotic strains protect against gastrointestinal infections, helps in balancing the gut microflora, reduces cholesterol, stimulates immune system to act against cells, helps in reducing the risk of occurrence of cardiovascular diseases and cancer [6].

Starter culture

LAB imparts several functional properties like improved digestion, inhibition of growth of harmful bacteria, reduction of risk of occurrence of cancer and cardiovascular diseases, alleviates hypercholesteraemic effect and lactose intolerance through its metabolic products produced during fermentation [7]. The starter culture used in certain fermented milk beverages are given in Table 1.

Table 1. Starter culture used in fermented milk beverages [2], [7]

Fermented milk beverage	Starter culture used
Yogurt drink / yogurt shake	*Lactobacillus bulgaricus* and *Streptococcus thermophilus*
Lassi, chaas and buttermilk	*Lactococcus lactis sp lactis* *Lactococcus lactis sp cremoris* *Lactococcus lactis sp diacetyllactis*
Kefir	Lactic acid bacteria (LAB), yeast, acetic acid bacteria
Kaumiss	*L. delbrueckii* sp. b*ulgaricus, L. acidophilus, Kluyveromyces marxianus* var. *lactis, Saccharomyces lactis, Torula koumiss, Saccharomyces cartilaginosus and Mycoderma* sp.
Acidophilus milk	*Lactobacillus acidophilus*
Probiotic milk	*Bifidobacterium* sp, *L. casei, Lactobacillus rhamnosus, Lactobacillus gasseri, S. thermophilus, Saccharomyces boulardii*

FUNCTIONAL PROPERTIES OF FERMENTED MILK BEVERAGES

The functional properties of the fermented milk products reflect their performance as ingredients in the final products [8]. The functional properties of the fermented milk beverages determine the behaviour of the individual component in the food product during various process like, thermal treatment, fermentation, cooling, agitation, packaging, filling and transportation. Fermented milk beverages are reported to reduce respiratory infections, improve the functioning of bone, liver, immune system, prevention of diarrhoea and constipation [9], [10], [11]. The probiotic starter culture of the fermented milk beverages aids in recovery from organ transplant, abdominal surgery and prevents the risk of occurrence of cardiovascular diseases and proliferation of pathogens in the gut [12]. They exhibit potential influence on brain health, relives stress, enhances memory, immune functions and possess neuroprotective effects. The fermented milk beverages alleviate inflammation, controls oxidative stress which might lead to cognitive dysfunction and neurodegenerative diseases [13].

Prevention of gastrointestinal disorders

Consumption of fermented milk beverages suppress the proliferation of pathogens in the host by production of secondary metabolites like lactic acid, peroxide, and bacteriocins [14]. The metabolites thus produced impart beneficial effect in reducing ulcers, diahhroea, helps to maintain gut microbial balance and enhances nutrient absorption in the host. The variation in concentration of resident colonic microbiota is caused from the effect of local and systemic immunity which leads to ulcerative colitis or Crohn's disease [15]. Probiotic bacteria are reported to reduce the severity by tapering corticosteroids in the host [2], [16]. The probiotic strains of *Bifidobacterium lactis* and *S. thermophilus* exhibits protective effect against nosocomical diahhroea in infants [17]. Similarly, fermented beverages with *B. animalis*, *L. acidophilus*, and *L. reuteri* acts against rotavirus diahhroea [11]. They are reported to reduce the occurrence of antibiotic infected diahhroea caused by *B. longum*, *B. lactis*, *Lactobacillus*, *L. acidophiluu*, *and Streptococcus faecum and yeast Saccharomyces boulardii* [13]. Lactic acid bacteria (LAB), especially *L. casei sp. rhamnosus* and several strains of *L. acidophilus* are known to inhibit *Salmonella typhimurium* [28], *Helicobacter pylori* [4] that causes diahhroea by production of antihelicobacter factors.

Fermented milk beverages for food fortification

The micronutrient deficiencies can be overcome by supplementation of food with required nutrient components which is termed as fortification. It can be achieved by application of fortification process like encapsulation, fermentation, blending, *etc.*, the fortified food is considered as functional food by American Dietetic Association (ADA) and are reported to exhibit health benefits when consumed on regular basis at effective levels [19]. Yogurt and cheese are reported to be used as vehicles for iron fortification in food products hence, yogurt drinks or shakes can be used similarly [20].

Fermented milk is considered as very effective vehicles for zinc fortification due to its acceptance for consumption among different population groups. Fermented dairy products is reported to be better fortificant vehicle for zinc as compared to cereal and plant- based sources since, cereals contain phytates that associates with metal ions and makes it unavailable for absorption, studies have reported negative correlation between zinc absorption and dietary phytates [21]. The phosphoserine residues of casein are the primary binding sites for Zn in milk that reduces the bioavailability, however at low pH ionisation of phosphoserine leads to reduced Zn binding thus increasing Zn absorption [22].

Antimicrobial property of fermented milk beverages

During fermentation, several peptides are formed as secondary metabolites that exhibit antimicrobial properties. The bioactive peptides are released as pro- peptides or mature C- or N- terminal peptides [18]. The most potent antimicrobial peptide formed from casein during fermentation are caseicidins, isracidins, casocidin-I, kappacin and lactoferricin [23]. The mechanism of antimicrobial action is by lysis of bacterial membrane to form channel that disrupt the cytoplasm of microorganisms. Fermentation by *Lactobacillus acidophilus* produces isracidin, a peptide that possess antimicrobial activity against Gram positive and certain Gram- negative organisms like *Streptococcus mutans*, *Escherichia coli* and *Enterobacter zakazakii* [24].

Antitumor property of fermented milk beverages

Invivo studies have suggested that fermented milk suppresses the multiplication of cancer cells [25]. It also has considerable effect against growth of human breast cancer. The antitumor property of fermented milk is reported due to stimulation of immune system to act against carcinogens and by enhancement of the population of intestinal microflora [26]. Fermented milk is found to reduce the activity of certain enzymes like β-glucuronidase, azoreductase, and nitro-reductase that catalyse the conversion of procarcinogen to carcinogens. Starter bacteria used in production of fermented milk is also known to exhibit antimutagenic property [26].

Antioxidant properties of fermented milk beverages

The antioxidant property of milk and milk products is attributed to the amino acids containing sulphur like cysteine and due to phosphate, carotenoids, zinc, selenium, superoxide dismutase, catalase, glutathione peroxidase, oligosaccharides and peptides produced during fermentation.

Yoghurt exhibited antioxidant property during storage period of 15 days analysed by ferric reducing antioxidant power (FRAP) and DPPH due to ascorbic acid and total phenolic content that inhibits the lipid peroxidation by reactive oxygen scavenging radicals [3]. Colonisation of lactic acid bacteria especially *Lactobacillus plantarum* in intestinal tract exhibit antioxidant properties [17].

Fermented milk beverages against allergy

Food processing and consumption pattern influence the concentration of LAB and probiotic bacteria. The reduction of which might lead to variation in intestinal microbiota as a result intestinal infections, allergies and atopic disease like eczema, allergic rhinitis and asthma prevails. *Bifidobacterium* exhibits protective effect against atopic eczema and allergic diahhroea [27]. The level of IgE in serum is altered by presence of *Clostridium*, *Bacteroides* and *Staphylococcus*. The gut microbiota influences the oral tolerance and immunity by reorienting the Th2 responder phenotype of new born infants for the Th1 cell mediated immune response and through the secretion of TGF and IgA. The micro-organisms colonised in gut alters immune response in atopic children by blocking the antigens present in food and microorganism across epithelium by regulation of gut barrier. LAB present in fermented dairy beverages modulates the homeostasis of the gut microorganisms thereby reduces the risk of occurrence and symptoms of allergy.

Effect of consumption fermented milk on blood lipids

Fermented milk is known to exhibit cholesterol lowering effect especially the total cholesterol and LDL cholesterol in normal as well as hypercholesterolemic adults [13]. The cholesterol lowering effect is reported to be due to formation of conjugated linoleic acid (CLA), deconjugation of bile salts, production of propionic acid that inhibits the expression of hepatic enzymes implicated in the de novo synthesis of lipids. The formation of hydroxymethylglutarate by LAB during fermentation inhibits hydroxymethylglutaryl-CoA reductases which is required for synthesis of cholesterol [26]. The metabolites formed by utilisation of orotic acid helps in lowering the serum cholesterol level. The reduction in cholesterol level in the consumer is reported to be due to deconjugation of bile acid by *Lactobacillus acidophilus* which does not absorb deconjugated bile acids as that of conjugated bile acids. *Lb. acidophilus* and *Bifidobacteria* actively assimilates cholesterol and other organic acids. The strains of *Lactobacillus fermentum* was also reported to reduce the cholesterol from the culture medium [29]. The activity of *Lb. acidophilus* is found to be higher than *Lb. casei* with respect bile salt deconjugation ability, bile salt hydrolase (BSH), and coprecipitation of cholesterol with deconjugation bile [14].

Enhanced lactose digestion by use of fermented milk beverages

Lactose intolerance is a malabsorption of lactose that leads to bloating, gassiness, nausea, abdominal pain, vomiting and uneasiness in individuals who lack β galactosidase enzyme that helps to digest lactose. Hence, lactose should be hydrolysed before consumption. During fermentation, lactose is converted into lactic acid which is well tolerated by such individuals [5]. The starter culture used in fermentation of milk contains substantial quantities of β galactosidase enzyme that helps in alleviating the symptoms of lactose malabsorption.

Stimulation of immune system by consumption of fermented milk beverages

Consumption of fermented milk beverages especially probiotic milk beverages containing *Lactobacillus acidophilus* and *Bifidobacterium sp* was observed to impart immunomodulation in the host. The impact on immune system is carried out by translocation of certain of ingested bacteria to Payer's patches of gut associated lymphoid tissue (GALT) in the small intestine through M cells. The probiotic starter of the fermented milk products is reported to stimulate cytokine production and enhance the activity of macrophages.

CONCLUSION

Fermented dairy beverages exhibit potential functional properties and health benefits contributed by the components present in it like lactose, protein, fat and starter culture. Yogurt drink, yogurt shake, *lassi, chaas, kefir, kaumiss, etc.*, are commercially and economically important fermented milk beverages. It aids in prevention of gastrointestinal disorders, alleviates lactose malabsorption, stimulates immune system and reduces allergy. Fermented milk beverages also possess anti- microbial, anti- viral and anti-tumor property.

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