Fermented Dairy Products for Health Benefits

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ABSTRACT

For thousands of years, fermentation has been used to increase the shelf life and preservation of foods and has been a part of daily nutrition, with no realization of the microbial functions and health benefits of fermented foods. Nevertheless, in recent years, it has been acknowledged that fermented foods and the microorganisms contributing to the fermentation process generate various beneficial effects on human health. It is known that fermented products are antioxidant, anti - radiogenic, anti - mutagenic, anti - thrombotic and have positive effects on cardiovascular diseases, cancer, hypertension, diabetes, immune system, hypercholesterolemia, lactose intolerance, inflammation, osteoporosis, and so on. The current study investigates the production stages of fermented dairy products and explores their interaction with health. The consumption of fermented milk products is recommended because of the microbiota, which consists of lactic acid bacteria and yeast, their high protein, vitamin and mineral content and their beneficial effects on health.

KEYWORDS
Fermentation, Dairy products, Nutrition, Health

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INTRODUCTION

Fermentation is one of the most ancient methods utilized for food preparation and preservation for centuries.[1] Since effective preservation methods were not widely used in ancient times, food fermentation was considered the most important method of maintaining food quality and ensuring food safety.[2] The growth and metabolic activities of microorganisms during fermentation enable the preservation of foods. Exposed to the effects of microorganisms or enzymes, foods go through several biochemical reactions.

Food fermentation can be divided into two categories: aerobic fermentation, such as fungal and alkaline, and anaerobic fermentation, such as alcoholic and lactic acid. During fermentation, microorganisms break down fermentable carbohydrates into end products such as organic acid, carbon dioxide, and alcohol, as well as anti-microbial metabolites such as bacteriocins that increase food safety by killing or inhibiting food-borne pathogens. The most widely used method of producing fermented products is lactic acid fermentation. In lactic acid fermentation, pyruvate molecules released through glycolysis are transformed to lactate. A wide range of lactic acid bacteria such as *Lactobacillus, Streptococcus, Enterococcus, Lactococcus, and Bifidobacterium* play a role in this transformation process.

These bacteria are utilized to produce fermented products such as yogurt, pickles, kimchi, and kefir. On the other hand, ethanol fermentation occurs through the transformation of pyruvate molecules to carbon dioxide and ethanol by various types of yeast. Bread, beer, and wine are widely produced by ethanol fermentation driven by metabolic activities of *Saccharomyces cerevisiae.* Fermentation enriches the diet by way of adding a variety of flavor, taste and aroma to foods, helps to preserve foods through lactic acid, alcohol, acetic acid and alkaline fermentations, enhances nutrients in food by proteins, essential amino acids, essential fatty acids and vitamins, and reduces the cooking time through detoxificatio. Furthermore, it is an economic method of food preparation that requires relatively little energy. Fermented foods are widely consumed in many cultures, as fermentation prolongs shelf life, enhances nutritional value and organoleptic properties of food, and increases the digestibility of protein and carbohydrates, and the bioavailability of vitamins and minerals. Besides the preservation of food, fermentation has a lot of positive effects on human health. Fermented foods induce beneficial effects on health by reducing blood cholesterol levels, increasing immunity, protecting against pathogens, alleviating carcinogenesis, osteoporosis, diabetes, obesity, allergies, and atherosclerosis, and relieving the symptoms of lactose intolerance.

LITERATURE REVIEW

Fermented Dairy Products

A broad range of fermented dairy products is produced by transforming the lactose in the milk composition into lactic acid *via* starter cultures. A way before knowledge about bacteriology was explored and brought into the light, starter cultures used to refer to the inoculation of a small amount of sour milk and fresh milk. In our day and time, fermented dairy products are produced through fermentation by lactic acid bacteria involving, *Lactobacillus, Streptococcus, Lactococcus, and Leuconostoc.* On the other hand, yeasts are used for the production of kefir and koumiss. Fermented dairy products have been considered as healthy foods since ancient times. The beneficial effects of fermented milk and milk products on health are associated with the fact that acidity of milk is increased by lactic acid bacteria during fermentation of lactose to lactic acid and the growth of pathogens is suppressed by the release of antibacterial agents such as lactic acid, peroxide, and bacteriocins. Having these characteristics, lactic acid bacteria are well-known for providing the fermented milk products with several beneficial and therapeutic properties, such as inhibition of harmful bacteria in the gastrointestinal tract, prevention of acute diarrhea, relief of lactose intolerance, and improved functioning of the immune system thanks to increased antimicrobial activity. The probiotic characteristics of lactic acid bacteria also support these beneficial properties and intestinal microbiot. Moreover, the health benefits of fermented foods are attributed to bioactive peptides synthesized through the microbial breakdown of proteins by the bacteria involved in fermentation. It is emphasized that fermented dairy products, thanks to these bioactive peptides, develop a wide range of positive effects such as hypotensive and hypocholesterolemic effect and suppression of tumor cells.

Examining the fermented milk products' biochemical mechanism that develops beneficial health effects, it is observed that angiotensin-1-converting enzyme (ACE) inhibitor peptides are formed during milk fermentation as milk proteins are degraded by proteinases in the cell wall of lactic acid bacteria. In other words, lactic acid bacteria generate bioactive peptides through initiating a proteolytic action on milk proteins. Due to the known antihypertensive effects of these peptides, especially valyl-prolyl-proline (VPP) and isoleucyl-prolyl-proline (IPP), fermented dairy products are recommended as a dietary strategy for the management of hypertension. Besides these peptides reflecting insulin-like adipogenic properties have therapeutic potential in the prevention of metabolic syndrome and diabetes. *Lactobacillus spp.,* one of the lactic bacteria contained in fermented dairy products, has been found to have positive effects in the treatment of hypertension-induced cardiovascular diseases. The mechanism reducing the total cholesterol level is associated with bacterial exopolysaccharides contained by fermented dairy products. Fermented dairy products are potentially beneficial for bone health as they are sources of calcium, phosphorus, protein, prebiotics and probiotics. In a prospective cohort study examining whether fermented milk products affect age-related bone mineral density (BMD) and microstructural changes, bone loss of those consuming fermented milk products was less than those who did not.[3-11]

Yogurt

Yogurt is defined as a coagulated dairy product that is produced by lactic acid fermentation induced by symbiotic bacteria cultures *Lactobacillus bulgaricus and Streptococcus thermophilus*. Traditional yogurt contains milk protein (2.7 %), milk fat (15 %), lactic acid (0.6 %) and appropriate proportions of microorganisms.

In traditional yogurt making, raw milk is boiled until it reaches nearly half of its volume. The boiled milk is cooled to 45 – 50 °C and the cooled milk is poured into clean earthenware pots. A small amount of the previous product (yeast) is added to the milk in the pots. The pots containing this mixture are wrapped around with leather to maintain a suitable temperature for fermentation and kept for 10-12 hours before being ready for consumption. As the yogurt reaches the appropriate pH (4.5), the pots are stored in the fridge. Although yogurt has the same micronutrient composition as milk, it is considered to have higher nutritional value as it contains more protein, vitamin B_{12}, B_6 and B_2, calcium, magnesium, potassium and zinc Also, the nutritional value of yogurt differs according to yeast, type of milk (whole, half, or skimmed milk), the origin of the milk (cow, goat, sheep, buffalo, camel), and fermentation conditions. The fact that yogurt has high nutritional value stays fresh for a long time if stored in a cold environment (3 – 10 °C), has low pH which renders impossible for pathogen microorganisms to survive for a long time are the fundamental reasons that make yogurt the most well-known and consumed dairy product in Turkey. The shelf life of yogurt is ten days at 4 °C and five days at 7 °C or one day at 25 - 30°C. If the storage period is exceeded, yogurt gets sour and spoiled and cannot be consumed.[12-20]

Strained Yogurt

It is an acidic, semi-solid and fermented milk product that is obtained from dry matter produced by filtering the serum part (whey) of classical yogurt. Strained yogurt is known by different names in different regions. While it is known as Greek yogurt, concentrated yogurt, strained yogurt or bag yogurt in Europe, it is named as Labneh, Peskuten, Labnehanbaris and Chanklich in the Middle East and Asia; Leben Zeer in Egypt, Chakka and Shirkland in India, Skyr in Iceland; Than or Ymer in Denmark; and Tan in Armenia. Different methods such as salting, cooking, leaching, increasing the amount of dry matter, and preventing aerification during heating and at storage are utilized to increase the resistance of yogurt to spoilage. Strained yogurt is particularly produced by communities living in hot climates to prolong their shelf life. In a study examining the microbiological properties of classical yogurt and strained yogurt, it was revealed that the volume of pathogenic microorganisms was reduced due to increased acidity in strained yogurt, and the shelf life of strained yogurt was much longer than that of classical yogurt the traditional method used in the production of strained yogurt in ancient times was based on the principle of placing the yogurt in animal skin for leaching; however, cloth bags are used for the same purpose in our day and time. Leaching is carried out at room temperature in the home environment. The duration of leaching varies depending on the characteristics of the cloth bags used; however, the overall process generally takes 20 to 30 hours. The length of the leaching period renders the method in question very unhygienic due to the high risk of microbial contamination. Yogurt, which sticks to cloth bags during leaching, cannot be removed completely, which causes loss of productivity. On the other hand, this method is rather preferred at homes as it does not require much equipment. Some soluble vitamins (thiamine, riboflavin) and minerals (calcium, phosphorus, and potassium) dissolve up to 50 – 70 % during the production of strained yogurt. Despite this disadvantage, the high amount of fat and protein contained in strained yogurt increases its nutritional value. Some studies have revealed that strained yogurt has higher nutritional value. The total dry matter contained by yogurt used for the production of strained yogurt is 10.8 - 13.32 %, the fat is 3.0 - 4.7 %, the protein is 2.5 - 5.8 %, lactose is 1.89 - 5.72 %, and the mineral substance is 0.35 - 1.12 %, whereas the total dry matter in the end product (strained yogurt) increases up to 18.00-26.96 %, fat up to 6.0 - 10.40 %, protein up to 4.46 - 9.22 %, mineral substance up to 0.56 - 0.82 %, and lactose up to 1.11 - 8.96 %. The bioactive peptides released by the breakdown of casein in fermented dairy products could emerge both *in vivo* by gastrointestinal processes and *in vitro* as a result of enzymatic hydrolysis of lactic acid bacteria such as Lactobacillus helveticus, Lactococcus lactis subsp. *cremoris, Lactobacillus delbrueckii subsp. bulgaricus* and induce positive effects on the cardiovascular system, nervous system, immune system and gastrointestinal tract. Due to the high protein content, strained yogurt is also rich in casein. Therefore, the consumption of strained yogurt is of great importance for human health.

Ayran: Ayran is a yogurt-based non-alcoholic Turkish beverage with a distinctive salty taste. It is known as "Dough" in Iran, "Tan" in Armenia, "Laban Ayran" in Syria and Lebanon, "Shenina" in Jordan, "Moru" in South India, "Laban Erbil" in Iraq, and "Ayrani" in Cyprus. In traditional ayran making, yogurt is diluted with 30 – 50 % water containing approximately 1 % salt. Salt makes sure the protection of the product against microorganisms, which also has an impact on organoleptic properties. Texture quality problems such as unpleasant, sour, bitter, acidic taste, clotted texture and serum separation are observed under insufficient hygiene and low-temperature storage conditions. The most obvious texture problem observed in Ayran is unavoidable serum separation generally occurring on the surface in the shape of yogurt-like acid gels. This situation is explained by milk proteins, whose colloidal stability is impaired by temperature and increased acidity, sinking to the bottom of the serum in which they are present, with the effect of density difference and force of gravity. Ayran reflects organoleptic properties that involve health benefits stemming from its nutritional value and offer desired aroma, taste and appearance. The nutritional elements of yogurt vary depending on the amount of water added. Ayran, a beverage rich in electrolytes, is of great importance in terms of replacing the water and mineral lost by the body through sweating.[21-29]

Kurut: Kurut is a traditional fermented dairy product produced by drying Yogurt or Ayran (buttermilk) after leaching, adding salt, and putting it into a specific shape. It is widely produced and consumed in countries where Turks live or which are influenced by Turkish culture. Known as "keys" or "cockle" in some regions of Turkey, it is named as Kashke in Iran, Kisk in Lebanon, Jub-Jub in Syria, Kusuk in Iraq, Aaruul in Mongolia and Quroot in Afghanistan. In traditional Kurut making, yogurt kept in the refrigerator for 24 - 48 hours is poured into a cloth bag and left to drain for 1 - 3 days. Strained yogurt is poured into a saucepan and cut into small pieces by spoon or hand to give 40 - 80 g of round, oval or conical shapes with 4 - 8 cm diameter. Optionally, salt (1 – 3 %) and cream (5 - 10 %) can be added before shaping. The pieces in shape are then placed in a tray and covered with a cloth and left to dry in a shaded and ventilated environment for 7 - 10 days. Then, they are left under the sun for 10 - 15 days. In some regions, ayran is boiled at 90 – 100 °C for about 10 minutes by stirring continuously until a white clot forms on its surface. At the end of the boiling process, the clot formed is removed and placed into a cotton bag and salt is added up to 2 - 3% of the weight of the formed product. Later, the bags are hung in a moisture-free room for 2 - 3 days and left to dry. Then, the product is taken out of the bag and shaped in a tray and dried under the sun for 10 - 15 days. To enhance the flavor, mint, dill, basil, red pepper, ginger, strawberry, raspberry and blackberry or beet and carrot juice can be added. Kurut contains large amounts of lactic acid bacteria and yeast. Its microbiota encompasses the isolates of *Lactococcus lactis ssp. lactis, L. helveticus, Streptococcus thermophilus, Lactobacillus delbrueckii subsp, Bulgaricus and Acetobacter spp.* While bacteria are responsible for lactic acid fermentation, yeasts initiate the formation of ethanol. Protein rate of Kurut increases at least 5.6 % before or after fermentation, and it is a highly nutritious food thanks to a high content of protein (6 %), calcium, potassium and phosphorus, low fat (5 %) and vitamin A, B_2, D, and E.

Yogurt and Health

Examining the beneficial effects of yogurt on health, it is revealed and acknowledged that yogurt has positive effects on reducing the risk of Type 2 diabetes, cardiovascular disease, hypertension and cancer, loss of body weight, diseases of the gastrointestinal tract, and diarrhea symptoms. In a study, it was reported that yogurt bacteria are useful in the treatment of gastrointestinal diseases such as Crohn's disease and ulcerative colitis. In a study examining the effect of fermented dairy product consumption on the risk of developing diabetes, yogurt consumption was found related to the decrease in the risk of developing Type 2 diabetes. It was also reported that the consumption of fermented dairy products increases insulin sensitivity thanks to the effects of the Lactobacillus helveticus bacteria contained in these products. In a meta-analysis study examining the relationship between yogurt consumption and Type 2 diabetes, it was revealed that there is an inverse relationship between the frequency of yogurt consumption and the risk of diabetes, and that yogurt consumption plays a potential role in preventing diabetes. In the study, it was concluded that yogurt may have probiotic effects that could modulate glucose metabolism. Also it was found that low-fat yogurt consumption reduced total cholesterol and LDL cholesterol levels in individuals having mild to moderate hypercholesterolemia. In addition, it was reported that there is an inverse relationship between yogurt consumption and CVD in hypertensive individuals. Furthermore, the DASH diet scores of the individuals consuming yogurt regularly were also found high. As a result, it was reported that hypertensive individuals who consume yogurt at least twice a week have a lower risk of developing cardiovascular disease. Increased yogurt consumption (> 5 servings / week) was associated with 16 % lower risk of hypertension in those with high blood pressure. In another study, body weight, BMI, waist circumference, body fat, plasma insulin level and, C-peptide concentrations of both women and men who consume yogurt were found to be lower than those who do not consume it. No significant relationship was found between total yogurt consumption and abdominal obesity and lower waist circumference in the elderly population. In a cohort study, it was reported that yogurt plus fruit consumption were inversely proportional to the risk of developing metabolic syndrome. Besides, yogurt consumption was found related to lower body weight, waist-to-hip ratio, and waist circumference, BMI, fasting total cholesterol, and insulin levels. In a study carried out on children and adolescents, high yogurt consumption was found associated with lower levels of body fat and risk of cardiovascular disease. In a case-control study, it was revealed that yogurt consumption and probiotic intake are linked with a low risk of colorectal cancer. Also yogurt consumption was found to be effective in cytokine production, T-cell function and natural killer cell activity and thus provides a general immunological enhancement. A positive correlation was found between the frequency of yogurt consumption and bone density, bone biomarkers and physical function indicators of elderly individuals (60 years and older). Another study concluded that yogurt consumption induced an increase in the composition of beneficial bacteria found in the intestinal microbiota. In a study conducted on elderly individuals, regular yogurt consumption was found to have a retarding effect on aging factors, accompanied by a wide range of nutritional deficiencies and health complications associated with malnutrition and overnutrition, including musculoskeletal disorders, immunosenescence, cardiometabolic diseases, and cognitive impairment.[30-39]

Cheese

Cheese, which contains carbohydrates, protein, fat, and minerals necessary for the human body, is of great importance in the daily diet. Milk, which gets spoiled in a short while due to its nature, becomes more durable when it is made into cheese. Therefore, cheese is one of the fundamental food substances that preserve its importance from the past to the present. The main steps in the conversion of milk into cheese are mainly composed of coagulation, leaching and ripening. Cheese is a fermented milk product consumed fresh or ripened, and produced by way of coagulating the milk with suitable proteolytic enzymes (rennin etc.) or organic acids, processing the formed clot in various ways, draining whey from the clot, pressing, shaping and salting it. The ripening of cheese is the most important step that provides the development of flavor, texture and aroma in cheese. Ripening is the result of the breakdown or degradation of acids, fats and proteins, depending on the metabolism of microorganisms and the activity of enzymes. Cheese microflora plays a significant role in the ripening process. There are two important microflora groups in cheese. The first one is the starter lactic acid bacteria (LAB), which produce acid and the majority of which reflect homofermentative characteristics, and the second one is the mixed microorganism group consisting of lactic acid bacteria, yeasts, other bacteria and mold. The most important function of lactic acid bacteria already present in milk or added later is to ensure the conversion of lactose to lactic acid during carbohydrate fermentation. Furthermore, lactic acid bacteria contribute to the microbial safety of the product thanks to the various antimicrobial substances they release. The lactic acid released enables the coagulation of milk with cheese yeast, separates the whey from the clot, improves the texture and flavor and preserves the product against pathogenic microorganisms. During the production phase, fermentation of lactose to lactic acid is realized particularly by thermophilic and *mesophilic streptococci*. Among these, the most important species are *Streptococcus salivarius ssp. thermophilus, Lactococcus lactis ssp. lactis, Lactococcus lactis ssp. cremori and Enterococcus faecalis.* Increased acidity is driven by lactic acid production and antimicrobial compounds produced by lactic acid bacteria ensure the inhibition of pathogenic microorganisms. The breakdown of lactic acid is the most important chemical phenomenon in the formation of taste and aroma in cheese. Lactate is degraded into compounds such as ethyl alcohol, acetate and CO_2 by lactic acid bacteria and yeast, and plays a role in the formation and improvement of taste and flavor in these products. The source of enzymes used in metabolic pathways that enable the development of flavor is starter cultures. Lactic acid bacteria such as *L. lactis, L. mesenteroides, S. thermophilus* and various Lactobacillus species are the widely used starter cultures. Cheese is produced in a wide variety of flavors and forms all over the world. These differences stem from the type of raw milk (cow, sheep, goat), coagulation method (acid, yeast), heat treatment procedure (raw, pasteurized), fat ratio (full-fat, half-fat, non-fat), texture (very hard, hard, soft), salt content (salty, unsalted), additives (various herbs and spices, melting salts, moldy), and ripening time (fresh, semi-ripened, ripened). Within the framework of coagulation methods in cheese making, white cheese, yellow cheese, and gouda cheese are coagulated by cheese yeast; cottage cheese and quark cheese are coagulated by harmless organic acid; curd cheese is coagulated by heat treatment. Cheese types produced and consumed the most in Turkey can be listed as white cheese, yellow cheese and Tulum cheese. In addition, Tire Çamur cheese, Kırktokmak cheese, Armola cheese, Sepet cheese, Kuru Ezme cheese, Örgü (eritme) cheese, Otlu cheese, Küp cheese, Çömlek cheese, Pesküten, Ekşi cheese, Ayran cheese, Civil cheese, İmansız cheese, Kolete cheese, Külek cheese, Minzi Kurut cheese, Oğma cheese, Teleme cheese, Telli cheese, Çimi cheese, Kelle Çökelek cheese, Ham Çökelek cheese, Sürk cheese, Nor cheese, Kelle cheese, Sütlü cheese, Gruyere cheese, Cacık cheese, Pestigen cheese, Çerkez cheese, and Abaza cheese are among those which are consumed the most by the community. In cheesemaking, enzymatic coagulation, acid coagulation and fermentation methods are used. In the enzymatic coagulation method, cheese is produced through coagulation started by the interaction of milk, rennin (rennet), salt, which is followed by the removal of whey, lactic acid production and salt addition.[40-53]

Cheeses Peculiar to Turkish Culture

Edirne Ezine Cheese: Ezine cheese is produced through mixing, in certain proportions, the milk of goat, sheep and cow, which are fed with natural vegetation and water sources. This rate is at least 40 % for goat's milk, 45 – 55 % for sheep's milk and 15 % for cow's milk. Ezine cheese is a product granted with a geographical indication registration certificate (origin name). In the production stage of Ezine cheese, the mixture containing a certain amount of goat, sheep and cow's milk, is pasteurized at 60 - 70 °C for 30 minutes and then fermented at 30 – 35 °C with the enzyme, obtained from the stomachs of the calves, to ensure clot formation. The clot is coagulated to separate whey and the leaching process is accelerated by applying pressure on cheese placed in special cheese molds. After the end product is cut into pieces, it is left to ripen in brine prepared using sea salt to reach the desired taste and aroma. Lactose left in the clot as a result of glycolysis reactions occurring during the ripening of cheese is degraded by microorganisms, and compounds such as lactate, acetate, butyrate, propionate or citrate are formed. The cheese molds taken out from the brine are lined up in tin plates and seasoned with dry salt and left to rest for 10 - 12 hours. As a result, the water inside is drained, brine is added on top, and the tins are closed and soldered in a way to prevent ventilation. So as to ensure that cheese has the desired characteristics and aroma, the tins are left to ripen in brine for 2 - 8 months at 2 – 4 °C in cold storage rooms.

Kars Gruyere and Yellow Cheese: Gruyere cheese is produced from cow's milk only, while Yellow cheese is made by mixing sheep's and goat's milk at a certain amount. In the production of Gruyere cheese, milk preserving its original temperature after milking is kept for a few more days in the so-called bath, where the temperature is 25 – 30 °C so that the cheese becomes slightly swollen and the pores are formed inside. After the bacteria in Gruyere cheese reproduce at optimum temperature and form the pores in the cheese, the cheese is left to rest for about 4 - 6 months to gain its aroma. What forms the pores in Gruyere cheese and gives its unique aroma and taste is *L. bulgaricus, S. thermophilus*, as well as *Propionibacterium shermanii*. The same steps followed in the production of Gruyere cheese are followed in the production of Kars Yellow cheese. Nevertheless, cow's milk is mixed with sheep's and goat's milk in Yellow cheesemaking, unlike the case in the production of Gruyere cheese. It has been determined that Kars Yellow cheese is characterized by high levels of protein and fat, which indicates the high milk quality of the cows fed with rich vegetation growing in the fertile soil of Kars. Furthermore, Kars Yellow cheese is registered with the geographical indicator.

Erzurum Küflü Cheese: Erzurum Küflü cheese registered with protected geographical indication is a type of cheese that is rich in protein, calcium and phosphorus, meets the animal protein needs of consumers, is fat-free or low in fat, and is ripened and dominated by greenish color. The main components are civil cheese and plain or curd cheese, which have salt-free, non-fat, or low-fat characteristics. In the production stage of civil cheese, the milk obtained from animals fed with various aromatic herbs grown on the high-altitude pastures of Erzurum, Turkey, is separated from its fatty part. Then, the remaining part is left to sour to a certain degree and then fermented. Civil cheese and plain cheese or curd is pressed into specific bags made of plastic, wood, or leather. Blue-green molds which develop spontaneously throughout the ripening process add a special taste and flavor to the cheese, which has a remarkable impact on its preferability by consumers (Republic of Turkey, Erzurum Provincial Directorate of Culture and Tourism)

Van Otlu Cheese: Van Otlu cheese having traditional characteristics and resembling white cheese with its production method differs in the endemic herbs it contains. Herbs added to cheese not only improve the taste and aroma but also extend the shelf life of the product due to their antibacterial and antioxidant properties (Van Provincial Directorate of Culture and Tourism) Sheep's milk is the main component of Otlu cheese; however, in the periods where sheep milk is scarce, goat and cow milk can also be added. Milk is filtered right after the milking process and fermented at the temperature it is filtered (about 30 ± 2° C). Commercial liquid yeasts or home-made yeasts prepared by mixing abomasum, black pepper, ginger, cinnamon, and cloves are used for fermentation. Following the formation of a clot in 1 - 2 hours depending on the type of yeast, the clot is divided into pieces and placed into cloth bags. In this process, the order of one layer of clot and one layer of the herb is followed. Endemic herbs such as (Sirmo), (Mendo), (Heliz), (Siyabu), (Dill), (Mint), and (Thyme) are washed well, chopped into small pieces and mixed by 2 % of the total amount of milk. Next, the opening of the bag is tied up and it is left to drain. Following 3 to 4 hours of draining process, the clot is cut into pieces and salted. Salted cheese pieces become ready for consumption after being left to ripen for 2 - 3 months.

Cheese and Health: Cheese is a high-quality fermented dairy product that is easily digested and well-tolerated and characterized by high energy, fat, protein, calcium, and vitamin B. Cheese contains calcium, phosphorus, sodium, and chloride. The bioavailability of calcium in cheese is quite high, which stems from the optimal ratio of calcium and phosphorus and the casein phosphopeptides' (CPP) inhibiting the formation of calcium salts which are insoluble in the intestine. Cheese comes to the forefront as an important nutrient in a diet with its benefits such as tissue repair. Protein content in cheese depends on the variety ranging from 4 % (cream cheese) to 40 % (Parmesan cheese). Furthermore, the digestibility of protein in cheese is quite high as the ripening phase involves the gradual breakdown of casein through releasing both amino acids and peptides *via* the enzymes already present in milk and those derived from cheese yeast or microorganisms. Factors involved in cheese making, such as treatment of milk with heat, starter cultures and ripening, have a significant impact on the increase in Conjugated Linoleic Acid (CLA) levels in cheese as some lactic acid bacteria used for milk fermentation are capable of producing CLA. The studies associating with the nutritional content of cheese with health emphasized antimicrobial, antihypertensive, antidiabetic, cholesterol-lowering, and risk-reducing effects on cardiovascular disease and cancer. In a study, diabetic mice were made to consume cheese for 35 days. Cheese consumption significantly increased glucose tolerance without affecting insulin secretion and led to a significant reduction in lipid peroxide markers. Also the hepatic lipid content in mice decreased dramatically. Another study concluded an inverse relationship between the frequency of cheese consumption and the risk of metabolic syndrome (MetS). Due to the sequence content released during fermentation of milk and the ripening process, cheese was considered as a potential source of ACE inhibitory peptides, and when inquired in deep, antihypertensive case-casein peptides were observed. Although cheese is regarded as a risk factor for cardiovascular diseases in some studies due to its high saturated fat (SFA) content, there are also studies reporting that it generates positive effects on atherosclerotic biomarkers by regulating lipid metabolism thanks to conjugated linoleic acid it contains. In a study on hypercholesterolemic individuals, it was observed that daily consumption of 2 servings (60 g) of cheese did not harm blood pressure or serum lipids. In a study, it was observed that the consumption of sheep milk cheese rich in rumenic acid by nature had beneficial effects on various atherosclerotic biomarkers. In another study, it was reported that the plasma of hypercholesterolemic subjects had an improved lipid profile and reduced endocannabinoid synthesis following the consumption of sheep milk cheese naturally enriched in CLA. In a study on mice, it was concluded that cheese consumption reduces the risk of metabolic syndrome. Besides, it was noted that the group consuming cheese had higher serum adiponectin concentration and lower liver triglyceride and cholesterol concentrations, compared to the control group. The anti-carcinogenic properties of cheese stem from conjugated linoleic acid (CLA) and sphingolipids. It is also stated that bioactive peptides. Contained in cheese increase weight loss, decrease glucose levels and insulin resistance, and isomer C18:2 Trans 9, trans 11 inhibits the growth of colon cancer cells in human. Butyric acid comprising 2 - 5 % of the milk fat in cheese is described as an anticarcinogenic agent that inhibits the growth of various cancer cells. The antiproliferation effect of cheese is associated with specific bioactive compounds released in the production process, because it is reported that the antiproliferative effect in question has not been observed in milk peptides. In a study, it was reported that the metabolites released during the fermentation of cheese protect HT - 29 and fibroblast CCD -18 Co cells against LPS-origin reactive oxygens. That cheese is characterized by high calcium and calcium bioavailability has been reported to have a positive effect on osteoporosis and tooth decay. Recent studies show that the use of probiotic cultures in cheese production increases the availability of calcium, magnesium and phosphorus. The stimulating effect of probiotic cultures on the availability of mineral compounds can be principally attributed to intensified enzymatic conversion, such as proteolysis. Also, cheese may be a good dairy alternative for the protection of bone health in individuals with lactose intolerance. Cheese comes to the forefront also with strong radical scavenger and antioxidant activity due to its β-casein and αs1-casein content. Antimicrobial properties of cheese are attributed to whey, as WSE of cheese contains organic acids and salts that can contribute to the inhibition of microbial growth.[54-73]

Kefir

Being a fermented dairy beverage with a sour, acidic taste, and creamy texture, kefir is produced through bacterial fermentation of kefir grains containing a mixture of microorganisms that are present together and interact with one another Rooted in the Caucasus kefir is named as "kephir, kefyr, kiaphur, kefer, kepi, knapon and kippi" in different geographical areas. The characteristic smell and flavor of kefir stem from volatile and non-volatile compounds such as lactic acid, acetic acid, pyruvic acid, hippuric acid, propionic acid, butyric acid, diacetyl and acetaldehyde produced by lipolysis, glycolysis and proteolysis. Depending on the carbon dioxide concentration contained by kefir grain, a small amount of alcohol may also be released. Kefir grains, the starter culture for kefir production, is a complex matrix consisting of exopolysaccharides and proteins and containing a microorganism mixture involving lactic acid bacteria acetic acid bacteria (Acetobacter) and yeasts (Kluyveromyces, Saccharomyces). Kefir grains can be described as 10 - 30 mm long, irregularly shaped, white and yellowish, lobed, tiny pieces with a solid texture and fine appearance looking like small cauliflower pieces or boiled rice. Kefir grains contain 4.4 % fat, 12.1 % ash, 45.7 % mucopolysaccharide, 34.3 % total protein (27 % insoluble, 1.6 % soluble and 5.6 % free amino acid), vitamins B and K, calcium, phosphorus, magnesium, potassium, sodium, iron, zinc and copper The fermentation process not only increases the health benefits of kefir but also enriches the content of vitamins B_1, B_{12}, K, folic acid, calcium, and amino acids. Besides, the fermentation increases the amount of ammonia, serine, lysine, alanine, and threonine compounds in kefir. It has been reported that kefir also contains tryptophan, valine, lysine, methionine, phenylalanine, threonine, and isoleucine. The nutritional value of kefir stems from its rich chemical composition consisting of minerals, proteins, peptides, vitamins, carbohydrates, and fats. The chemical composition of kefir depends not only on starter kefir grains, but also on fermentation conditions differing by geographical origin, temperature and time, and the type and volume of milk used. In traditional kefir production, kefir grains are added to milk to start the fermentation under eligible physical conditions. Fermentation finalizes in nearly 22 hours at 25 °C. Following the fermentation, grains are removed from the end product aseptically. The process can be repeated by putting the grains into milk again. It is observed that kefir grains grow and increase in volume over time.

Kefir and Health

Potential health benefits of kefir, such as anti-stress, immune modulation, antihypertensive, cholesterol-lowering, antidiabetic, antiallergic antimicrobial, anticancer, are linked to its complex microbiota and composition formed by various microorganisms and fermentation metabolites. Sugar found in kefir is known as kefiran, which is a heteropolysaccharide with glucogalac origin in nature. Kefiran exhibits antibacterial properties that modulate the intestinal immune system and protect epithelial cells against pathogenic bacteria. Besides, this antimicrobial property can be attributed to the presence of hydrogen peroxide, peptides (bacteriocins), ethanol, carbon dioxide, diacetyl and organic acids (lactic and acetic acids). The importance of the antimicrobial property of kefir stems from its ability to limit the survival of some of the pathogenic bacteria species. In a study, it is reported that kefir consumption enhances beneficial microorganisms such as Lactobacillus and Bifidobacterium, and reduces pathogenic microorganisms such as Clostridium perfringens. It has also been noted that these beneficial microorganisms inhibit the pathogenic properties of microorganisms in the intestinal microbiota. In addition to its antimicrobial properties, kefiran also reduces blood cholesterol levels by capturing enterohepatic circulating cholesterol in the gut. Kefir has been found to inhibit fat accumulation in adipose tissue and liver tissues, decrease body weight, and reduce serum triacylglycerol (TG), total cholesterol (TC) and low-density lipoprotein (LDL) levels in obese mice induced by high fatty diet. In hypercholesterolemic mice fed with Lactobacillus plantarum, one of the Tibetan kefir grains, it was found that kefir consumption lowered LDL cholesterol and TG levels without affecting HDL cholesterol. Moreover, it is suggested in a study that the downregulation of Niemann-Pick C1-Like 1 (NPC1L1), a critical protein for intestinal cholesterol absorption in Caco - 2 cells, is effective in reducing cholesterol levels *via* kefir consumption In another study, it was found that kefir consumption decreased serum total cholesterol, serum LDL cholesterol, serum triglycerides, liver cholesterol and liver triglycerides in hypertensive and stroke-prone mice fed with fatty diet. It was demonstrated that kefir stimulated macrophage activation of bioactive peptides, creating a natural immune-activated response and increasing NO production, phagocytosis and cytokine production (TNF-α, IL-1 and IL-6) production. Serine, threonine, alanine, lysine, valine, isoleucine, methionine, phenylalanine and tryptophan play an important role in the functioning of the central nervous system. Also, branched-chain amino acids in kefir facilitate the cognitive recovery of patients with severe traumatic brain injury. In the study conducted to determine the effect of kefir consumption on glucose and lipid profile control in patients diagnosed with Type 2 diabetes mellitus, it was reported that the case group, compared to the control group, had lower HbA1C and fasting blood sugar levels after the intervention. Another study revealed that kefir consumption in overweight or obese premenopausal women stimulated a significant improvement in serum lipid profile. In a study conducted on diabetic mice, it was put forward that kefir consumption caused an anti-diabetic effect by reducing plasma glucose levels and providing improved insulin release through increasing the glutathione peroxidase (GPx) activity. The ACE-inhibitory activity of kefir biopeptides is associated with the suppression of angiotensin-converting enzyme, the capacity to clear superoxide radiation, and the decrease in blood pressure. It is suggested that kefir may reduce the cancer risk with the help of bioactive compounds and polysaccharides it contains, and the cancer cell inhibition mechanism works through inducing apoptosis by way of stopping the cell cycle, regulating the BAX up and regulating the BCL2 genes down. In addition, strengthening of the immune system is another mechanism inducing the antitumor effect. It is also assumed that the anticarcinogenic effect is driven by sulfur-containing amino acid groups. Containing partially digested protein (casein), kefir helps the digestive system. Yeast, which is present in the starter culture of kefir, plays an important role in establishing an eligible environment that allows the growth of kefir bacteria as well as the production of several key metabolites such as peptides, amino acids, vitamins, ethanol and CO_2 that contribute to the flavor and aroma of kefir. Lactic acid is effective not only in the formation of sour taste of kefir but also in the inhibition of the reproduction of pathogenic microorganisms in the intestines owing to decreasing pH through increasing the acidity. It is reported that the kefiran part of kefir prevents diarrhea and enterocolitis by way of enhancing the population of Bifidobacteria, which embodies probiotic characteristics. β-galactosidase present in kefir grains by nature reduces the lactose content through hydrolysis; thus, Kefir becomes a good option for people with lactose intolerance. Besides, regular consumption of kefir limits the activity of IgE and IgG. Hence, improved intestinal microflora may allow the prevention of food allergy and increase mucosal resistance to gastrointestinal pathogen infections. Thanks to its probiotic properties, kefir contributes to lowering the incidence of allergic diseases by increasing the volume of Bifidobacterium and *Lactobacilli*.[74-100]

Koumiss

Koumiss is a traditional fermented dairy beverage with a slightly alcoholic, sour taste produced by using unpasteurized raw mare milk. Rooted back in Central Asia, koumiss derives from the name Kumanese, a Kumane River tribe in the Central Asian steppes. Also known as chige, chigo, arrag or airag in different regions, this fermented dairy product is largely consumed in Western and Central Asian countries such as Kazakhstan, Mongolia, Kyrgyzstan, China, and Russia. In the traditional koumiss production, koumiss yeast (20 percent or 3 to 4 tablespoons) remaining from the last production is mixed into 5 liters of fresh mare milk. The mixture is poured into a leather sack called "saba" or "turdusk". Meanwhile, koumiss undergoes two main fermentation processes: lactic acid fermentation and alcohol fermentation. The microorganisms starting the fermentation processes are the lactic acid bacteria *(Lactobacillus delbrueckii subsp. Bulgaricus ve Lactobacillus acidophilus, L. casei, L. lactis ssp. lactis*) converting lactose into lactic acid and the yeasts *(Saccharomyces spp., K. Marxianus var, Marxianus and Candida koumiss, Saccharomyces and Mycoderma spp.*) converting sugar into carbon dioxide and ethyl alcohol. Fermentation continues at room temperature (~ 20 – 30 ° C) for 1 - 3 days. Throughout the fermentation process, fermented mare milk is stirred with a wooden stick to ensure the production of lactic acid, ethanol and aroma, accelerate fermentation, remove carbon dioxide, ensure homogeneity and prevent the spread of pathogens. At the end, fermentation causes the ethyl alcohol content dropping down to 2 % and the pH below 4. The end product is stored at 4 °C to prolong its shelf life. While the conversion of lactose into lactic acid by lactobacillus bacteria gives koumiss its unique sour taste, fermentation of sugar into ethyl alcohol and carbon dioxide leads it to be a slightly carbonated and alcoholic beverage. In industrial production of koumiss, Lactobacillus delbrueckii subs. Bulgaricus is added into pasteurized skimmed cow milk as a starter culture and it is incubated for 30 minutes at 70 °C. Following the incubation, a second culture containing Torula spp. is added into the mixture and left to incubate for 15 - 18 hours at 28 - 30 °C. To obtain the bulk starter to be used in koumiss production, mare milk is slowly added into the mixture until it reaches approximately 0.7 % acidity (LA) at 28 °C incubation temperature. Milk is left to fermentation for 3-4 days until it reaches 1.4 % acidity. The starter culture obtained is added into fresh mare milk by 30 %. Koumiss is incubated at 28 °C by shakin until the acidity (L.A.) reaches 0.5 % (approx. 1 hour is needed). Later, koumiss put into bottles with sealed lids is left to incubate for 2 hours at 18-20°C. After the incubation, bottles are stored at -5 °C for 24 hours before consumption Koumiss contains 90 % water, 2-2.5 % protein (1.2 % casein and 0.9 % whey protein) 5 – 6 % lactose, 1 – 3 % fat and 0.3 % ash, 2 % alcohol and lactic acid (0.7 % 1.8), ethanol (0.6 - 2.5 %), and CO_2 (0.5 - 0.9 %). The carbon dioxide released as a result of fermentation gives the product a foamy texture like soda or champagne. Lactic acid and alcohol content of koumiss is much higher than that of other fermented dairy products such as yogurt and kefir, and it is associated with a high sugar content of mare milk, which contains low nitrogen, low casein and high lactose. Furthermore, koumiss contains vitamins B_1, B_2, B_{12}, and fat-soluble vitamins A, E, D and, vitamin C. It is also rich in calcium and trace elements Rich nutritional value and probiotic microorganisms it contains have led koumiss to be considered as a functional food.[101-127]

Koumiss and Health

Koumiss positively impacts on kidney and liver health, endocrine system (regulation of blood sugar level), digestion (lactose intolerance), nervous, immune (anti-inflammatory) and cardiovascular systems (regulation of cholesterol and blood pressure), as well as its healing effects on anemia, avitaminosis and gastrointestinal diseases. Also, it facilitates detoxification of the body, retards cell-aging, and has antibacterial, antiviral and antifungal properties. It is also utilized in the treatment of respiratory diseases (tuberculosis, bronchitis, whooping cough) and migraine pain. As lactose is degraded into lactic acid and ethanol during fermentation, koumiss may not cause diarrhea and abdominal pain, which are the common symptoms of lactose intolerance. It is reported that the antibacterial compound of Saccharomyces cerevisiae which is available in koumiss can inhibit the growth of pathogenic *E. coli in vitro*. Hence, the importance of koumiss in terms of gastrointestinal diseases is emphasized. In a study conducted on individuals diagnosed with gastrointestinal tract diseases, it was found that consumption of koumiss for 60 days significantly reduced fecal interleukin-38 and tumor necrosis factor-ɑ level. Besides, the level of some stool proinflammatory markers decreased after koumis consumption. Because probiotic bacteria in koumiss play an important role in the regulation of cytokines such as IL-10, IL-12, Koumiss is described as a food substance exhibiting anti-inflammatory properties. In a study conducted on patients with hyperlipidemia, it was reported that koumiss consumption had a positive effect on blood lipid profile, hypertension and dyslipidemia. In another study, it was revealed that koumiss consumption significantly increased high-density lipoprotein cholesterol (HDL) concentrations while decreasing immunoglobulin G and albumin levels to a remarkable extent. This finding points out that koumiss alleviates the symptoms of hyperlipidemia. It was suggested in the study that the effect of koumiss on blood lipid profile is associated with the bacterial composition, especially Lactobacillus and Streptococcus species, and the metabolites contained by koumiss such as s-adenosyl-1-methionine, carnosine, lysophosphatidylinositol and dipeptides. In a study, it was reported that Koumiss positively impacts on individuals with cardiovascular disease through facilitating and enhancing calcium absorption. Another health benefit of koumiss is to stimulate the growth of granulation tissue and support wound healing in dermatological disorders. It was observed that koumiss consumption soothes dermatological problems stemming from dry skin caused by psoriasis itself, medications used or negative effects of phototherapy. [128-148] The above-mentioned health benefits of koumiss are attributed to the orotic acid it contains. In addition to delaying skin aging, orotic acid is also suggested to prevent liver cirrhosis and non-alcoholic steatohepatitis. [149-168]

CONCLUSION

Fermented dairy products (food and beverages) have been an integral part of human nutrition throughout centuries. Comprehension of the importance of preventive healthcare practices in recent years has rendered the food-health interaction a greater subject of interest. For this reason, the relationship between fermented dairy products and health has been investigated. Milk proteins are a good source of bioactive peptides, and they are released as a result of proteolysis induced by fermentation of lactic acid bacteria and yeasts during the production of dairy products. Also, various vitamins such as vitamin B_2 (riboflavin), vitamin B_9 (folate), vitamin B_{12}, and vitamin K increase during fermentation. Due to these characteristics, fermented dairy products come to the forefront with several health benefits such as cholesterol-lowering, immunomodulator, antioxidant and anti-cancer, antihypertensive, anti-inflammatory, antidiabetic, anti-adipogenic, anti-mutagenic, anti-thrombotic and anti-atherogenic. Considering the rich microbiota and composition of fermented dairy products containing lactic acid bacteria, yeasts, high levels of protein, vitamin, and mineral which yield a broad range of benefits on health, it is recommended for adults desiring to have a healthy and balanced diet to consume 3 portions of dairy products per day, i.e. one portion refers to one glass of milk (240 mL) or a bowl of yogurt (200 - 240 g) or two matchbox-sized cheese (approx. 40 - 60 g), and for kids, adolescents, pregnant and nursing women and women in the post-menapausal period to consume 2 to 4 portions of milk and dairy products.

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