**Food Supplements Used in Functional Dairy Products**

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**ABSTRACT**

Functional dairy products; dairy products containing probiotic and / or prebiotic milk, enriched dairy products, low-calorie milk products, low-sodium dairy products, and phenylalanine amino acid. Dairy products with probiotics constitute the most important group of functional dairy products. In studies on symbiotic, probiotic and prebiotic combinations have more positive effects on human health. Functional dairy products can be produced by the addition of ω-3 polyunsaturated fatty acids, minerals, vitamins, soluble fibers and antioxidants. In addition, functional dairy products with reduced energy value, sodium, lactose or phenylalanine amino acids are produced for feeding people with certain diseases. It is obvious that functional dairy products are significant in terms of health and nutrition. The most important point in including these products in our daily diet; is the development of consumer cognizance and related scientific studies.

**Keywords:** functional dairy products; food supplements

**I. INTRODUCTION**

Recently, nano foods, novel foods, and functional foods have grown in importance as a result of significant changes in consumer demand. Today, food is consumed to eliminate hunger and to get the necessary nutrients, as well as to increase the physical and mental health of consumers and to prevent nutrition-related diseases [1]. Functional food has been defined by a committee of members of the Functional Food Science in Europe (FUFOSE) program as "a food that, beyond adequate nutritional effects, can be sufficiently demonstrated to beneficially affect one or more target functions in the body in a way that significantly improves health and well-being and/or reduces the risk of disease". The functionality of a food may be related to the fact that it naturally contains ingredients with provable health characteristics: a food in which an ingredient has been removed or added by biotechnological and technological means. Additionally, the bioavailability of one or more of the food ingredients and the nature of one or more of the ingredients may be affected. A functional food may target certain consumer groups (such as lactose-free products) or the general population (such as probiotic beverages) [2].

The most widely researched and selected food groups that include food ingredients for functional purposes are dairy products. Milk, condensed milk, fermented milk drinks, infant milk formulas, powdered milk, butter, cheese, cream, colostrum, ice cream, kefir, and yogurt are the most common traditional dairy products accepted as functional foods. These products have components that greatly improve human health. Vitamins, minerals, and proteins found in dairy products are important nutrients. However, it is becoming increasingly common to include dairy supplements and milk-based food products such as vitamin D, calcium, Omega-3 fatty acids, prebiotic polysaccharide, probiotic bacteria, and other compounds. As well, there may be situations where certain hazardous components must be reduced, removed, or replaced [3]. The production of functional products in the food industry and consumers demand for these products is increasing daily [2]. Therefore, newly developed functional dairy products may be listed as follows:

- Products containing probiotics and/or prebiotics

- Enriched

- Low-calorie

- Low-sodium

- Dairy products from which the amino acid phenylalanine has been removed

**II. FUNCTIONAL FOOD SUPPLEMENTS**

**A. Functional Microorganisms and Food Supplements in Probiotic and/or Prebiotic Containing Dairy Products**

**Probiotics**

Experts from Food and Agriculture Organization and World Health Organization define probiotics as “live microorganisms that have a positive effect on host health when consumed in sufficient quantities as part of food” [4]. These microorganisms are non-pathogenic organisms of human origin, have antagonistic effects against pathogens, do not produce toxins, are resistant to bile salts and acid, can live in the intestinal tract, adhere to intestinal cells, stabilize the intestinal microbiota, form antimicrobial compounds and maintain their viability in storage [5]. Probiotics are natural components of most fermented milk products, but many fermented products have no well-defined strains of probiotic. Therefore, new approaches have emerged in functional dairy products, such as the addition of probiotic strains to fermented or non-fermented products and the application of probiotic-based fermentation. Probiotics are classified as next-generation probiotics (NGPs), traditional probiotics based on LAB, and non-LAB probiotics. The exhaustive classification of probiotic strains and their commercial uses is presented in Figure 1. Most bacterial probiotics belong specifically to the *Lactobacillus* genus LAB. Other important genera of LAB are given as follows: *Lactococcus*, *Leuconostoc*, *Vagococcus,* *Carnobacterium*, *Oenococcus, Weissella, Tetragenococcus, Enterococcus, Streptococcus, Sporolactobacillus*, *Pediococcus* and *Aerococcus*. Non-LAB probiotics (or non-traditional probiotics) include some strains of several species belonging to the genera *Bacillus*, *Bifidobacterium*, *Clostridium*, *Escherichia*, *Enterococcus,* and probiotic yeast (*Saccharomyces* spp.). NGPs are identified as “living microorganisms defined based on the relative microbiota analysis that, when applied in acceptable quantities, provide a health benefit to the host”. NGPs are more suitable for administration through a pharmaceutical product [6].

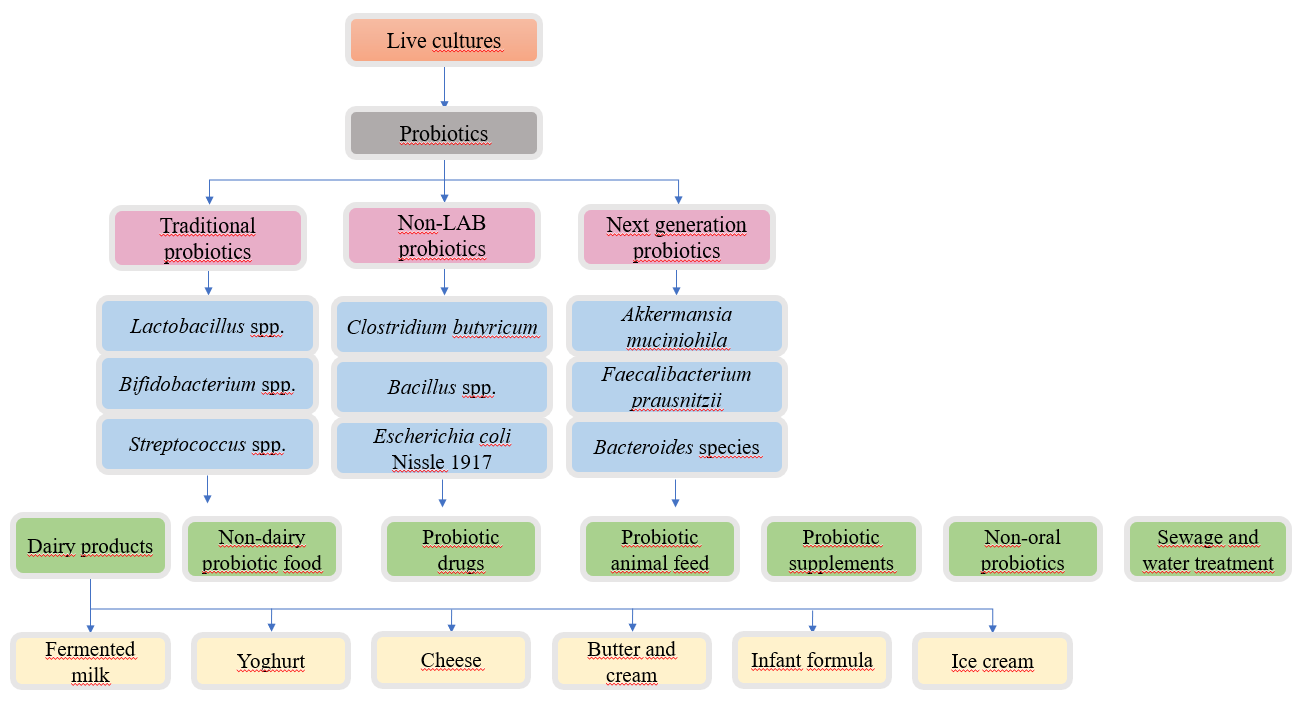


Figure 1. Detailed classification of probiotic strains and their commercial uses [6]

In general, probiotic strains used in dairy products appertain the genera *Bifidobacterium* and *Lactobacillus*. *Saccharomyces cerevisiae Boulardii* is the only yeast whose probiotic properties have been proven. Microorganisms that have been most studied and proven effective in the studies; *B. animalis*, *B. lactis*, *L. rhamnosus*, *L. caseii*, *L. casei Shirota*, *L. acidophilus*, and *S. cerevisiae Boulardii* [7]. Although some probiotic strains can reproduce in milk at the desired rate, other strains need growth-stimulating substances. Probiotic strains can be added before the fermentation of the milk as well as to the fermented product obtained after fermentation [8].

The most popular way to add functional properties to dairy products is to add live probiotic microorganisms to the minimum recommended level. A type of probiotic that can guarantee health effects of a food product has no cell count rate. However, it is reported that a level of 106 to 108 cfu/g is enough to take advantage of the benefits of probiotics [6]. The viability of probiotic bacteria is affected by different factors. These factors are lactic acid and hydrogen peroxide produced during fermentation, the amount of dissolved oxygen in the product, the presence of protectives in the product, the interaction between species, oxygen permeability of the packaging, and storage conditions. Additionally, it is stated that the increase in acidity during the storage of probiotic dairy products adversely affects the viability of probiotic bacteria [9]. Furthermore, probiotic microorganisms should show antagonistic effects against carcinogenic substances and pathogenic microorganisms. It must produce antimicrobial agents and be able to produce beneficial effects in the host, such as resistance to disease. It should be resistant to antibiotics. Food should be able to maintain its vitality and activity during production and storage. Probiotic microorganisms should not produce toxins and be non-pathogenic. It should be suitable for the preparation of multistrain preparations. It should be able to be metabolized in the intestine without being affected by adverse environmental conditions such as bile salts and low pH. It should be able to attach to intestinal cells, and colonize the small intestine [5]. Lactobacilli such as *L. paracasei, L. casei, L. gasseri, L. rhamnosus,* *L. reuteri*, *L. acidophilus* and bacteria such as *B. longum,* *B. adolescentis* *B. bifidum, B. breve* with probiotic properties adapt to conditions of the stomach and there is a suitable environment for their growth in the small intestine [8].

**Prebiotics**

Prebiotics are commonly identified as “non-digestible food ingredients that positively affect the host by selectively stimulating the activity and/or growth of one or more limited bacterial species in the gut, consequently effectively improving host health”. Although the notion of prebiotics is actually a different mechanism, it has the identical purpose as probiotics to enhance host health through modulation of intestinal flora [10]. Prebiotics are low-molecular-weight and relatively short-chain carbohydrates. Prebiotics have been proven to readily penetrate, usually through the large intestine, and act as substrates for the endogenous colonic bacterial population [11]. Prebiotics are resistant to digestive enzymes and are fermented and used by the intestinal microbiota. Prebiotics support the growth of *Bifidobacterium* spp. and *Lactobacillus* spp. In addition, it provides functional properties by producing metabolites such as short-chain fatty acids for the host [12].

Commonly, beneficial prebiotics are generally divided into three main categories; polyol (sugar alcohols), oligosaccharides, and soluble fibers [11]. The most common prebiotics in food ingredients are specified as oligosaccharides. Although oligosaccharides remain unmetabolized in the small intestine, they can be fermented in the colon region, especially with advanced enzyme systems of species of *Lactobacillus* and *Bifidobacterium* [13]. Figure 2 shows the main ingredients studied and used as prebiotic components. The prebiotics that has more evidence of their positive effects on health are non-digestible carbohydrates such as galactans (galactooligosaccharides) and fructans (fructooligosaccharides and inulin). These prebiotics are gotten by biotechnological means or from natural sources. Inulin and FOS are branched or linear structural polysaccharides. Lactulose is a disaccharide composed of galactose and fructose. Other compounds such as oligosaccharides, isomaltooligosaccharides, raffinose family oligosaccharides, polyols, non-starch polysaccharides, and starch polysaccharides have been investigated for their prebiotic potential. Most prebiotics are based on carbohydrates. Recent findings point to other compounds with prebiotic properties, such as carotenoids, phenolic compounds, vitamins (some B vitamins and vitamin K), and polyunsaturated fatty acids. These bioactive compounds stimulate the development of beneficial commensal microbiota and modulate the intestinal ecosystem by preventing the proliferation of pathogens [14].

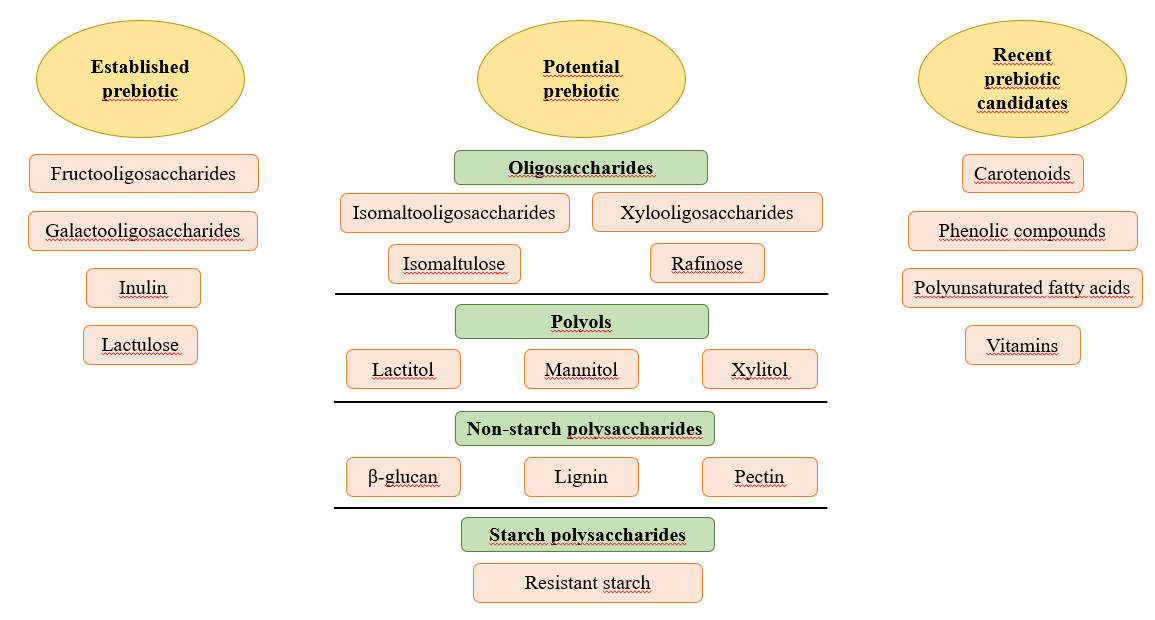


Figure 2. Main ingredients studied and/or used as prebiotic components [14]

Prebiotics have been proven to have antagonistic effects against pathogenic microorganisms. Therefore, prebiotics have a significant effect to enhance the health-beneficial activities, survival, development, and metabolism of probiotics in the digestive environment. Due to their excellent bioactivity, prebiotics are known as an important energy source, especially for bacteria [11]. Prebiotics are beneficial for intestinal health, reduce the risk of cancer formation, prevent constipation and obesity, and support the immune system. In addition, they also benefit bone health [12]. Additionally, as a result of prebiotic fermentation, which is complex dietary fibers, by the human intestinal microflora, a short-chain fatty acid is formed and affects insulin sensitivity and energy metabolism of the butyrate molecule [13]. According to the level of evidence of their effects on health, prebiotic components are isomaltooligosaccharides (IMO), xylooligosaccharides (XOS), galactooligosaccharides (GOS), fructooligosaccharides (FOS), and raffinose (RFO) (Figure 2). The use of prebiotics in dairy products depends on the concentration of prebiotics, the type of prebiotic, and the food matrix. It also has a positive impact on the sensory, rheological, and physicochemical properties of the product [14].

**Synbiotics**

Synbiotics are described as blends of prebiotics and probiotics that beneficially influence the host by developing the persistence and implantation of live microbial nutritional supplements in the gastrointestinal tract of the host [10]. At the same time, they are also known as a combination of probiotics and prebiotics, in which they are in a synergistic relationship. A synbiotic product supports the proliferation of beneficial bacteria and the survival of live microbial food supplements in the gastrointestinal tract. Probiotics are active in the small and large intestines. On the other hand, prebiotics contribute to the growth of probiotics in the large intestine [12]. While *S. boulardii*, *Lacbobacilli, B. coagulans,* and *Bifidobacteria* spp., etc. are among the probiotic strains used in synbiotic formulations, the main prebiotics used are XOS, GOS and FOS, inulin, prebiotics from natural sources [15].

According to the regulations, when synbiotic dairy products reach the consumer, they must contain a specific number of live probiotic bacteria. Therefore, preserving probiotics is a must [11]. With the fermentation reaction of foods rich in prebiotics, their probiotic content is enriched, and they gain synbiotic properties. Foods with synbiotic properties contain approximately 104-109 cfu/g of live probiotic bacteria during their shelf life. These products have many positive effects by correcting intestinal digestive problems, lowering LDL cholesterol and hypertension, protecting mental health, preventing atherosclerosis, preventing obesity, protecting against cancer, balancing immunity, and regulating glucose metabolism. In addition to the synbiotic characteristic of fermented foods, they also have beneficial properties, such as easy digestion and a high content of essential amino acids and beneficial vitamins [16]. After prebiotic fermentation by probiotics and the microbiota, an increase occurs in short-chain fatty acids such as propionate, acetate, and butyrate [12].

**B. Food Supplements Used in Enriched Dairy Products**

Food fortification is done to prevent the loss of vitamins and minerals in the human body, to replace the nutrients lost during food processing, or to supplement the nutrients that are present in small amounts in the food. For food fortification; the stages of determining the target population, the food fortification tool, and the additive level, evaluating the sensory suitability of the enriched food, confirming whether it has sufficient bioavailability, and the budget are important. In addition, the enrichment agent; should be resistant to inhibitors, safe, stable, and not change the character of the food. It is necessary to determine the legal minimum level of all enrichment agents and the maximum tolerable level of enrichment agents whose excessive consumption carries a health risk [17].

In functional dairy technology, milk is commonly enriched with minerals and vitamins [18]. Many health problems occur in the deficiency of mineral ions. These ions are involved in many physiological processes, including maintenance of pH and regulation of enzyme activity, osmotic pressure, and electrical stability of cell membranes. Milk contains a significant amount of micronutrients [19]. Milk and dairy products are sources of important minerals, especially magnesium and calcium. However, they also contain trace amounts of iron, zinc, selenium and iodine [20]. Calcium is the most abundant element in milk (120 mg/100 g). Sodium, magnesium, phosphorus, and potassium are also found in milk. The micronutrient components of dairy products are different from milk. Although butter and cream are poor sources of micronutrients, fermented milk is a good source of several nutrients such as calcium, phosphorus, potassium, zinc, and magnesium. Cheese is a good source of phosphorus and calcium and contains higher amounts of selenium, zinc, and iodine than natural milk [19].

Calcium is present in a colloidal form as a caseinate-phosphate complex that is easily released during in vivo digestion and is of high potential bioavailability. Therefore, milk is widely used for additional calcium delivery [20]. Drinking milk produced by fortifying milk with calcium is more focused on [18]. The recommended daily intake of calcium for adults is approximately 900 mg/day and approximately 1200 mg/day for adolescents and the elderly. Adults get about 70% of their calcium especially cheese. Although milk provides a high amount of calcium, there is some debate as to whether it is biologically better than other sources such as calcium salts, mineral waters, or some vegetables [21]. Various milk and dairy products enriched with calcium have beneficial effects in preventing osteoporosis. To increase immunity, dairy products are enriched with immunoglobulins. The hormone melatonin, which controls the day and night rhythms of the human body, is used at high rates in dairy products to prevent insomnia. For this purpose, functional dairy products have been developed in many countries. The role of casein phosphopeptides (CPP), which is a functional milk component, is basically to increase the bioavailability of calcium, and for this reason, dairy products containing CPP and enriched with milk proteins have recently been sold [8]. Calcium has recently been added to milk in a mixture of minerals such as Mg, P, and vitamins [18]. Milk and dairy products make an important contribution to the dietary intake of magnesium. These products are essential dietary sources of magnesium, especially for children, and contribute approximately 10.30% of total magnesium intake. As a result of the understanding of the importance of magnesium in the milk system, the potential for the development of milk and dairy products to increase bioavailable magnesium levels has been demonstrated [20].

Zinc is the most abundant trace element in the body after iron and is required for many basic physiological functions such as body growth, reproduction, immunological defense, perception of taste and smell, and mineralization of bones. The daily zinc requirement determined by the European Union Commission is 10 mg, and this rate varies between 4.7-18.6 mg in different countries. Dairy products are estimated to meet the daily zinc requirement between 19% and 31%. Studies are carried out on the enrichment and bioavailability of zinc-poor milk and dairy products with zinc. Histidine and cysteine amino acids are reported to increase the biostability of zinc [17]. Milk has low zinc content. For this reason, adequate zinc intake for adults and adolescents (8 mg/day) cannot be achieved with natural dairy products [19]. The study of Zn enrichment in milk levels consumed by adolescents is reported to positively affect Zn uptake and absorption. Therefore, it is recommended to consume fortified milk for more than 27 days to provide physiological requirements and sufficient Zn level [20].

Iron is an essential element in human nutrition. Iron deficiency causes many health problems such as physical fatigue and weakening of brain functions and a decrease in the rate of pregnancy. Women of childbearing age, infants, and children are at high risk of iron deficiency [22]. Iron supplementation in foods is the easiest way to ensure daily intake and prevent iron deficiency. Due to its high bioavailability, milk and dairy products are used for iron supplementation [20]. Milk is a low-iron food (0.2 mg/kg). In iron fortification, food, and iron compounds must be matched well to ensure optimal iron biostability and avoid rancidity. While vitamins A, C, and E have a positive effect on iron absorption, Ca, P, and Mg have a negative effect. Therefore, interactions between nutrients must be taken into account. Furthermore, due to the poor biostability of inorganic iron, larger amounts of iron are needed, which can have damaging effects. For this reason, attention should be paid to properties such as solubility, stability, taste, color, and oxidation [23]. Fat oxidation in milk and yogurt enriched with iron sulfate, ammonium, and ferric reduces iron absorption in fortified milk. The oxidized and metallic flavors differ depending on the catalytic role of iron and the presence of iron salts, respectively, in iron-enriched yogurt. Although ferric ammonium citrate provides oxidation in milk, it does not cause oxidation in solid dairy products [24].

Selenium, an essential mineral for human nutrition, is found in very low amounts in milk and dairy products [20]. The concentration of Se in cow's milk can vary between 2-1270 μg/L. The concentration and chemical form of ingested Se affect the nutritional bioavailability and toxicity of Se. Research are carried out on the enrichment of products such as brine, cheese, baby food powder, whole milk powder, and milk with Se [19]. Fermentation of Se-enriched milk has been reported to be suitable for improving the uptake of various organic selenium compounds. Iodine is inherently found in minor amounts in milk. Several studies highlight the beneficial effect of consuming milk fortified with iodine. Especially in the lactation period, iodine-fortified milk is accepted as a good food source to provide iodine sufficiency [20].

Vitamins are compounds that act as cofactors in the body. Fermented dairy products are a source of vitamins. In addition, fermented milk products have different vitamin content, thanks to the ability of some starters to synthesize vitamin B, which is necessary for their growth. However, processes such as temperature, incubation time, heat treatment, and storage conditions change the vitamin content in the fermented milk product. Under ambient conditions, water-soluble vitamin C and B complex group vitamins, such as riboflavin, pantothenic acid, niacin, folic acid, biotin, thiamine, vitamin B6, and vitamin B12 are powdered and easy to use. Fat-soluble vitamins are found in crystals and can cause processing difficulties during the production of some dairy products. Vitamins have limited stability in the presence of oxygen, temperature, and humidity. The fat-soluble vitamins A, D, and E are the least stable. Many different coating technologies, such as microencapsulation, have been developed to increase the stability of these vitamins [24]. Vitamin D3 deficiency is a major problem for children and adults worldwide. Vitamin D3 maintains serum calcium in the normal range, its deficiency causes osteoporosis and fractures in adults and rachitis in children. In addition, vitamin D3 deficiency increases the risk of diseases such as hypertension, infectious diseases, and cancer. The main source of vitamin D3 for humans is sunlight. Supplementing foods with vitamin D3 is an important factor in the absence of sunlight. For this reason, the use of vitamin D3-fortified milk in cheese-making is becoming widespread [25].

**C. Food Supplements Used in Low-Calorie Dairy Products**

The Turkish Food Codex defines foods in different ways, such as reduced-energy, low-energy, non-energy, non-sugar, non-fat, and low-fat, depending on the compatibility of the ingredients with the conditions. The expression ‘‘reduced energy’’ from these definitions is used for foods whose energy value has been reduced by at least 25% compared to the original product. It is also used for those containing less than 3 g of fat in 100 g of low-fat solid food or 1.5 g in 100 mL of liquid food, and those containing less than 0.5 g of sugar in 100 g of non-sugar solid or 100 mL of liquid food [26]. The composition of milk fat in dairy products can be changed by reducing the saturated fatty acid ratio and increasing the content of fatty acids that are more desirable in the human diet, such as ω-3 polyunsaturated fatty acids (PUFAs) [24]. Light milk, yogurt, cheese, and kefir are produced, which are prepared by reducing fat and replacing fat. In this way, the energies of the products are reduced, and their rheology is controlled [18].

In many countries, plant sterols are added to functional dairy products. Polyunsaturated Omega-3 fatty acids have a significant place in fortified milk [8]. Omega-3 is effective in the treatment of asthma, Crohn's disease, and hypertension. It also reduces the risk of serum triglyceride levels and coronary artery disease. There is an inverse correlation between Omega-3 fatty acid consumption and the frequency of Alzheimer's [27]. Omega-3 fatty acids are also important for the development of nerve and brain tissue. Its deficiency also causes problems such as visual disturbances, memory loss, depression, and schizophrenia. The most important Omega-3 fatty acids are docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA). The main sources of these fatty acids are formed by unicellular phytoplanktons and seaweeds [28]. It also accumulates in seafood throughout the food chain [29]. Dairy products such as fermented milk and yogurt are good products for Omega-3 supplementation due to their high frequency of consumption, as well as ideal storage conditions [2]. In recent years, it has become important to enrich dairy products such as cheese, yogurt, and drinking milk by adding EPA and DHA and to introduce new special nutritional foods to the food market. Dairy products are suitable for enrichment with EPA and DHA because they are widely consumed in our daily diet, stored at low temperatures, have a short shelf life, and are packaged in nonair and light-permeable packages. To avoid adversely affecting the sensory and physical properties of the product in enrichment with EPA and DHA, the appropriate amount to be added to each product must be determined. The characteristics of the food to be enriched (water and fat amount, aroma addition), unwanted fish taste, and oxidation are among the factors limiting the number of fatty acids [29].

Reduced sugar dairy products are suitable for people with lactose intolerance. Lactose intolerance is due to inadequate lactose resorption in the small intestine due to absence or decreased activity of β-galactosidase. As a result, undigested lactose reaches the colon, where it is fermented by the colon microbiota, producing lactate, methane, and hydrogen which causes symptoms such as bloating, diarrhea, and stomachache. Due to these negative effects, lactose-intolerant consumers cannot consume milk and foods containing lactose [30]. In recent times, consumption of LF-UHT (lactose-free UHT) milk has increased in many countries. Varying degrees of lactase deficiency (hypolactasia) affects approximately 70% of the world's population. LF-UHT milk is more susceptible to spoilage than normal UHT milk. This is because LF-UHT milk contains large amounts of reducing monosaccharides. Monosaccharides are more reactive than lactose by joining in the Maillard reaction during the storage and heating process of milk. During LF-UHT milk production, the formation of prebiotic galactooligosaccharides (GOS) can occur through transglycosylation reactions [31]. Today, many different lactose-free dairy products are produced with lactase processing technology and lactose concentrations fall below 0.1% [32]. In dairy products, lactose is reduced by the controlled action of purified β-galactosidases. In the applied lactose hydrolysis technique, lactase is added to the milk to be processed [2]. Most cheeses are naturally lactose-free or contain very low levels, since lactose is converted to lactic acid in the early stages of cheese ripening during fermentation by starter bacteria [32].

**D. Food Supplements Used in Low-Sodium Content Dairy Products**

Salt (NaCl) is the diet's primary source of sodium. It is added to products for many functional reasons such as microbial stability, flavor enhancer, and texture [33]. Sodium in processed foods is an important public health concern, as it contributes to the development of hypertension, which may be a precursor to conditions such as cardiovascular disease in some people [34]. In addition, excessive salt consumption causes various health problems, such as kidney stones and stomach cancer, and hurts harms on calcium absorption in human metabolism, which can negatively affect bone health [35]. In addition to these harmful effects, concerns about the relationship between dietary sodium and cardiovascular disease have led to a reduction of salt in processed foods [36]. Today, studies are carried out to rearrange products, especially in the dairy sector, as a result of the efforts of public health institutions to reduce the salt content of foods, health warnings published in the media, and consumer demands for a healthy life [35].

Dairy products contain important nutrients such as vitamin A, vitamin D, magnesium, potassium, calcium, and protein, but dairy products, like cheese, are high in sodium. The salt content of cheeses varies between 4-6% in brine cheeses and 0.5-0.7% in acid curd cheeses. Salt inhibits pathogen growth and provides control of harmful microorganisms; therefore, if salt levels are reduced in products such as cheese, protectives may be added to provide shelf life and safety [33]. Salt helps producers control several important cheese parameters such as final moisture content, microbial activity, survival of starter bacteria, and enzymatic activity. For these reasons, it is difficult to reduce the salt in cheese. The salt content of cheese also directly affects flavor and texture. However, low-sodium cheeses often exhibit an acidic flavor as a result of excessive acid production during manufacture due to the first stage of the ripening process caused by the starter culture activity facilitated by low moisture-salt levels [36]. Mineral salt modifiers can be added to maintain enzymatic and microbial stability by protecting the water activity (aw) of the cheese. However, salt modifiers can affect aroma by creating undesirable tastes, such as bitter and metallic, and flavor enhancers can be used to suppress these tastes [34].

**E. Functional Properties and Food Supplements in Dairy Products from which Phenylalanine Amino Acid is Removed**

Phenylketonuria (PKU), a congenital metabolic disorder, is caused by the insufficiency of the phenylalanine hydroxylase (PAH) enzyme [37]. In other words, PKU is an autosomal recessive metabolic disorder that occurs in the insufficiency of the PAH enzyme, which converts the amino acid of phenylalanine to the amino acid tyrosine, or its cofactor. The increase in the amount of phenylalanine, an essential amino acid, in the blood causes central nervous system damage and, consequently, cognitive disorders [38]. To prevent brain damage caused by this disease, it is necessary to reduce the level of phenylalanine in the body. For this reason, there are products prepared for patients with phenylketonuria and consumed commercially, and laboratory studies are also carried out in the direction of the development of new products [39]. Foods allowed in the diet for PKU are low in protein and should not exceed the recommended limit for phenylalanine (0–20 mg/100 g) [37].

Dietary therapy and nutrition continue to be a central focus in the treatment of PKU [40]. Although diet therapy is successful in preventing mental disability in PKU patients, diet therapy has problems with taste and nutritional deficiencies, especially vitamins B12 and D [41]. Foods for patients with phenylketonuria can be divided into three groups: foods containing all essential nutrients except phenylalanine, foods with reduced phenylalanine content, and foods that control blood levels of phenylalanine. Milk has a rich protein content and is a good source for the production of protein hydrolyzate. However, due to the high phenylalanine content, casein and whey proteins must be hydrolyzed and then removed from the environment to release aromatic amino acids [38].

The use of glycomacropeptides (GMP) and large neutral amino acids (LNAA) in dietary therapy has been investigated in recent years. LNAAs, tryptophan, tyrosine, Phe, and branched-chain amino acids share the same amino acid transport system across the blood-brain barrier. Tyrosine and tryptophan supplementation has shown improved serotonin and dopamine metabolism in PKU patients, but this is only appropriate for adults who do not adhere to a low Phe diet [41]. A low phenylalanine whey-based protein substitute called glycomacroprotein (GMP) has been developed [40]. Glycomacropeptide (GMP), glycolysate containing 64 amino acids, is a natural protein source [42]. GMP is a protein obtained from whey that is naturally low in Phe and rich in threonine, valine, and isoleucine [41]. It is found in the whey protein of cow's milk. Approximately 25% of the whey protein of fresh cheese is GMP. GMP is used safely in these patients because it does not contain phenylalanine. Milkshakes and fruit pudding can be counted among foods and beverages containing GMP [42]. Short-term studies in humans and mice have shown less degradation of L-amino acids, slower absorption, and better protein uptake with glycomacroprotein compared to amino acids without Phe [40]. In addition, studies have shown that phenylketonuria patients like foods containing glycomacroprotein more than regular amino acid formulas and prefer a diet fortified with glycomacroprotein [41].

**III. CONCLUSION**

Milk and dairy products constitute an important part of the diet. For this reason, it is possible to obtain the necessary nutrients by increasing the functional properties of these products. Increasing the functionality of milk and dairy products has an important place both commercially and nutritionally. Dairy products containing probiotics constitute the most important group of functional dairy products. Studies on synbiotics show that probiotic and prebiotic combinations have more positive effects on human health. In addition to these, minerals, vitamins, and Omega-3 polyunsaturated fatty acids etc. with the addition of supplements, functional dairy products can be produced. In addition, functional dairy products with reduced energy, sodium, lactose, or phenylalanine amino acids are produced for the nutrition of people with certain diseases. As a result of the food supplements made for these products, studies on the development of new milk and dairy products with higher nutritional value and better organoleptic and quality properties continue. The most important point in including functional milk and dairy products fortified in our daily diet is to increase relevant scientific studies and consumer cognizance.

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