

# FOOD SUPPLEMENTS USED IN FUNCTIONAL DAIRY PRODUCTS

## Abstract

Functional dairy products include enhanced dairy products, low-calorie milk products, low-sodium dairy products, probiotic and/or prebiotic milk, and phenylalanine amino acids. Products that include probiotics make up the most significant group of functional dairy products. Combinations of probiotics and prebiotics have been shown to have a greater beneficial impact on human health in research on symbiotic relationships. Functional dairy products may be produced by including Omega-3 polyunsaturated fatty acids, minerals, vitamins, soluble fiber, and antioxidants. Furthermore, functional dairy products with a lower calorie value, sodium, lactose, or phenylalanine amino acids are manufactured for feeding people with particular disorders. Functional dairy products are clearly important in terms of health and nutrition. The most significant aspect of incorporating these products into our everyday diet is the advancement of consumer consciousness and associated scientific investigations.

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

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## I. INTRODUCTION

As a consequence of major changes in customer demand, nano foods, novel foods, and functional foods have recently gained prominence. Food is now consumed to satisfy hunger and provide essential nutrients, improve consumers' physical and mental health, and avoid nutrition-related diseases [1]. A functional food is defined 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" by a committee of members of the Functional Food Science in Europe (FUFOSE) program. A food's functionality may be attributed to the fact that it naturally contains ingredients with proven health properties; a food in which an ingredient has been removed or added using biotechnological and technological techniques. Furthermore, the bioavailability and nature of one or more of the food ingredients may be affected. Functional foods may be intended for certain consumer groups (such as lactose-free products) or for a wider population (such as probiotic beverages) [2].

Dairy products are the most extensively investigated and chosen food group for functional purposes. The most popular traditional dairy products regarded as functional foods include milk, condensed milk, fermented milk beverages, infant milk formulas, powdered milk, butter, cheese, cream, colostrum, ice cream, kefir, and yogurt. These products include ingredients that significantly improve human health. Dairy products include important nutrients such as vitamins, minerals, and proteins. However, dairy supplements and milk-based dietary products containing vitamin D, calcium, Omega-3 fatty acids, prebiotic polysaccharides, probiotic bacteria, and other substances are becoming more widespread. Also, certain dangerous components may need to be minimized, removed, or replaced [3]. The food industry is producing functional products, and customer demand for these products is increasing daily [2]. Therefore, newly developed functional dairy products may be listed as follows:

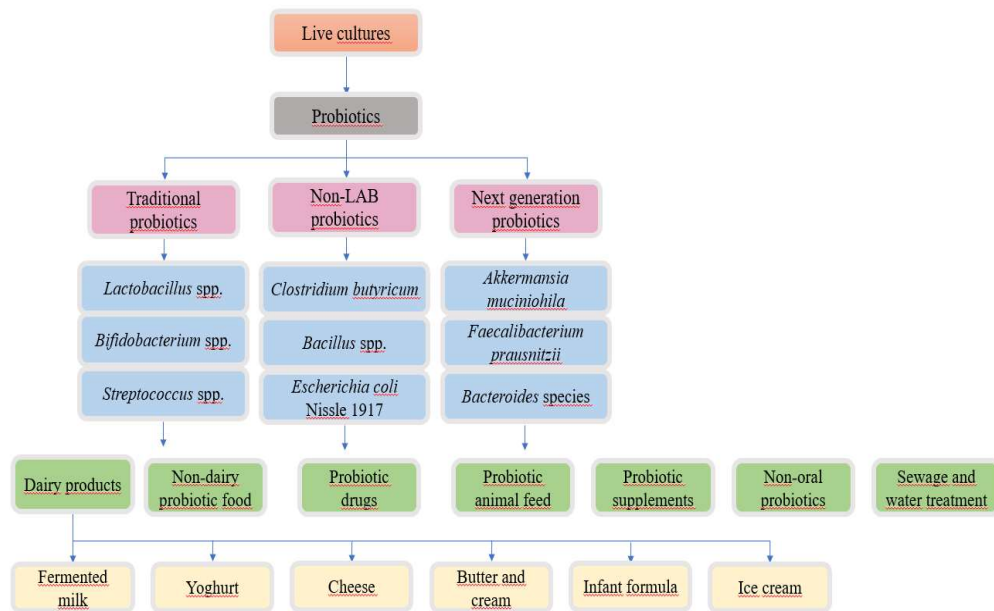
- Products containing probiotics and/or prebiotics
- Enriched
- Low-calorie
- Low-sodium
- Dairy products from which the amino acid phenylalanine has been removed

## II. FUNCTIONAL FOOD SUPPLEMENTS

### 1. Functional Microorganisms and Food Supplements in Probiotic and/or Prebiotic Containing Dairy Products

- **Probiotics:** Probiotics are defined by experts from the Food and Agriculture Organization and the World Health Organization 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 that 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 retain viability in storage [5]. Probiotics are naturally present in most fermented milk products, although many fermented products lack well-defined probiotic strains. As a result, new methods for

functional dairy products have arisen, such as the addition of probiotic strains to fermented or non-fermented products and the use of probiotic-based fermentation. Probiotics are classified as next-generation probiotics (NGPs), traditional probiotics based on LAB, and non-LAB probiotics. Figure 1 shows the thorough classification of probiotic strains and their commercial use. Most bacterial probiotics belong specifically to the *Lactobacillus* genus. 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 belong to the genera *Bifidobacterium* and *Lactobacillus*. *Saccharomyces cerevisiae Boulardii* is the only yeast whose probiotic properties have been proven. *B. animalis*, *B.lactis*, *L. rhamnosus*, *L. caseii*, *L. casei Shirota*, *L. acidophilus* and *S. cerevisiae Boulardii* are the microorganisms that have been investigated the most and proven to be effective in studies [7]. Although some probiotic strains can reproduce in milk at the desired rate, other strains need growth-stimulating substances. Probiotic strains can be added to both the milk before fermentation and the fermented product after fermentation [8].

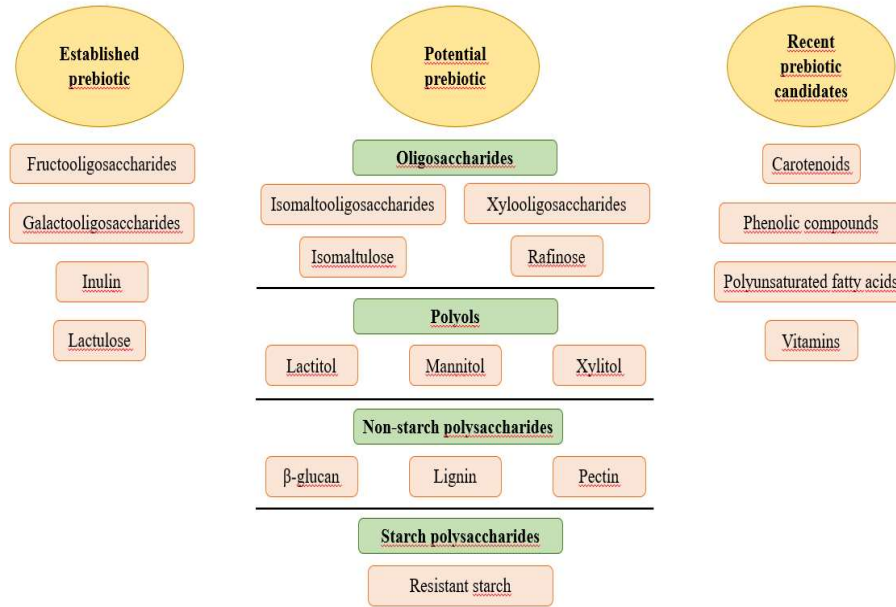
The most popular way to add functional properties to dairy products is to add live probiotic microorganisms to the minimum recommended level. A type of

probiotic that can guarantee the health effects of a food product has no cell count rate. However, a level of  $10^6$  to  $10^8$  cfu/g is reported to be sufficient to take advantage of the benefits of probiotics [6]. There are various factors that affect the viability of probiotic bacteria. 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 protective's in the product, the interaction between species, the oxygen permeability of the packaging, and storage conditions. The increase in acidity during storage of probiotic dairy products is reported to adversely affect the viability of probiotic bacteria [9]. Furthermore, probiotic microorganisms ought to have an antagonistic effect on both carcinogenic substances and pathogenic microorganisms. It must produce antimicrobial agents and be able to produce beneficial effects in the host, such as disease resistance. 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 nonpathogenic. It ought to be able to undergo metabolism in the intestine without interference from potentially harmful environmental factors like 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*, and *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 usually described as "non-digestible food ingredients that benefit the host by selectively stimulating the activity and/or growth of one or more limited bacterial species in the gut, thereby effectively improving host health". Although prebiotics are a different mechanism; they have the same purpose as probiotics in improving host health by modulating intestinal flora [10]. Prebiotics are carbohydrates with a low molecular weight and a short chain. Prebiotics have been proven to easily 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 utilized by the intestinal microbiota. Prebiotics support the growth of Bifidobacterium spp. and *Lactobacillus* spp. Additionally; it provides the host with functional useful properties by generating metabolites such as short-chain fatty acids [12].

Beneficial prebiotics are often categorized into three groups: polyols (sugar alcohols), oligosaccharides, and soluble fibers [11]. Oligosaccharides are the prebiotics commonly found in food ingredients. Despite not being digested in the small intestine, oligosaccharides can be fermented in the colon, particularly when species of *Lactobacillus* and *Bifidobacterium* with advanced enzyme systems are present [13]. The main ingredients investigated and utilized as prebiotic components are shown in Figure 2. Non-digestible carbohydrates like galactans (galactooligosaccharides) and fructans (fructooligosaccharides and inulin) are prebiotics with the most scientific support for their beneficial effects on health. These prebiotics can be obtained either through biotechnological means or from natural sources. Inulin and FOS are branched or linear structural polysaccharides. Lactulose is a disaccharide consisting of galactose and fructose. The prebiotic potential of other

compounds has been studied, including oligosaccharides, isomaltooligosaccharides, raffinose family oligosaccharides, polyols, non-starch polysaccharides, and starch polysaccharides. Most prebiotics are based on carbohydrates. Other compounds, such as carotenoids, phenolic compounds, vitamins (including various B vitamins and vitamin K), and polyunsaturated fatty acids, might also have prebiotic qualities, according to recent research. 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 on pathogenic microorganisms. As a result, prebiotics have a considerable influence on the health-beneficial activities; survival, growth, and metabolism of probiotics in the digestive environment. Prebiotics are renowned as a crucial energy source, particularly for bacteria, due to their excellent bioactivity [11]. Prebiotics are beneficial for intestinal health, reduce the risk of cancer formation, prevent constipation and obesity, and support the immune system. Additionally, they support bone health [12]. In addition, prebiotic fermentation of complex dietary fibers by the human intestinal microflora results in the formation of a short-chain fatty acid, which influences the butyrate molecule's energy metabolism and sensitivity to insulin [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 usage of prebiotics in dairy products depends on the concentration of prebiotics, the type of prebiotic, and the food matrix. The sensory, rheological, and physicochemical properties of the product are also positively impacted [14].

- **Synbiotics:** Synbiotics are mixtures of prebiotics and probiotics that help the host by making it easier for live microbial nutritional supplements to stay in the host's gastro intestinal tract and settle there [10]. They are recognized as a synergistic combination of probiotics and prebiotics at the same time. 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 both the small and large intestines. On the other hand, prebiotics support the development of probiotics in the large intestine [12]. While *S. boulardii*, *Lactobacilli*, *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, and prebiotics from natural sources [15].

By regulation, synbiotic dairy products must include a certain quantity of live probiotic bacteria when they reach consumers. 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  $10^4$ - $10^9$  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. Fermented foods have a synbiotic quality, but they also have positive qualities, easy digestion, a high quantity of essential amino acids, and beneficial vitamins [16]. Short-chain fatty acids, including propionate, acetate, and butyrate, increase as a result of prebiotic fermentation by probiotics and the microbiota [12].

2. **Food Supplements Used in Enriched Dairy Products:** Food fortification is done to prevent the loss of vitamins and minerals in the 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 acceptability of the enriched food, confirming whether it has sufficient bioavailability, and determining the budget are important. The enrichment agent should also be safe, stable, inhibitor-resistant, and not change the quality of the food. The legal minimum level of all enrichment agents, as well as the maximum tolerated level of enrichment agents whose excessive use poses a health risk, must be established [17].

In functional dairy technology, milk is commonly enriched with minerals and vitamins [18]. Many health problems due to a deficiency of mineral ions. These ions are involved in many physiological processes, including the maintenance of pH and regulation of enzyme activity, osmotic pressure, and electrical stability of cell membranes. Micronutrients are present in milk in significant amounts [19]. Milk and milk products are rich in minerals, especially magnesium and calcium. However, they also contain trace amounts of iron, zinc, selenium, and iodine [20]. Calcium is the most prevalent element in milk (120 mg/100 g). Milk also contains sodium, magnesium, phosphorus, and potassium. The micronutrient components of dairy products are different from those of milk. While fermented milk is an excellent source of several minerals, including calcium, phosphorus, potassium, zinc, and magnesium, butter and cream are

poor suppliers of micronutrients. Cheese is richer in selenium, zinc, and iodine than natural milk and is a good source of phosphorus and calcium [19].

Calcium is available in colloidal form as a caseinate-phosphate complex, which is easily released during in vivo digestion and has a high potential for bioavailability. As a result of this, milk is widely used for additional calcium delivery [20]. More emphasis is placed on drinking milk produced by adding calcium to milk [18]. The recommended daily intake of calcium for adults is about 900 mg/day, whereas the amount for adolescents and the elderly is about 1200 mg/day. Adults often acquire 70% of their calcium from cheese. Although milk has high calcium content, it is contested whether it is biologically superior to other sources of calcium, such as mineral waters, calcium salts, or some vegetables [21]. Numerous calcium-enriched milk and dairy products are helpful in avoiding osteoporosis. Dairy products are fortified with immunoglobulins to boost immunity. The hormone melatonin, which regulates the bodies day and night rhythms, is widely employed in dairy products to prevent insomnia. Functional dairy products have been produced in many countries for this reason. Casein phosphopeptides (CPP), a functional milk component, mainly help to boost the bioavailability of calcium, which is why dairy products fortified with milk proteins and containing CPP have lately 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 are significant sources of magnesium in the diet. These products make up around 10.30% of the overall magnesium intake and are crucial dietary sources of magnesium, especially for children. Understanding the significance of magnesium in the milk system has made it possible to develop milk and dairy products that have higher quantities of bioavailable magnesium [20].

The body needs zinc for several fundamental physiological processes, including bone mineralization, immune system defense, body growth, and reproduction. Zinc is the second-most prevalent trace element in the body after iron. 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 done on the enrichment and bioavailability of milk and dairy products with zinc that are deficient in zinc. According to several reports, zinc's biostability is improved by histidine and cysteine amino acids [17]. Milk has low zinc content. This means that natural dairy products are unable to provide adults and teenagers with an appropriate zinc intake of 8 mg per day [19]. The research on Zn enrichment in milk levels ingested by adolescents reports that it positively affects Zn uptake and absorption. To meet physiologic needs and provide a suitable Zn level, it is advised to take fortified milk for more than 27 days [20].

Iron is an essential element in human nutrition. Iron deficiency results in a variety of health issues, such as physical exhaustion, weakened brain functions, and decreased fertility. Women of child bearing 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. Milk and dairy products are utilized as iron supplements because of their high bioavailability [20]. Milk has a low iron content of 0.2 mg/kg. In iron fortification, food, and iron must be well matched to ensure optimal iron biostability and avoid rancidity. Iron absorption is positively impacted by vitamins A, C, and E while negatively impacted by vitamins Ca, P, and Mg. Therefore, interactions

between nutrients must be taken into account. Additionally, higher amounts of iron are required due to the poor biostability of inorganic iron. However, this can have a negative impact. Because of this, consideration should be given to qualities such as solubility, stability, flavor, color, and oxidation [23]. Iron absorption in fortified milk is decreased by fat oxidation in milk and yogurt that have been supplemented with iron sulfate, ammonium, and ferric. 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 causes oxidation in milk, it has no effect on the oxidation of 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 influence its nutritional bioavailability and toxicity. Research is being done on the enrichment of products with Se, including brine, cheese, baby food powder, whole milk powder, and milk [19]. Fermentation of Se-enriched milk has been reported to be suitable for improving the uptake of various organic selenium compounds. Iodine is naturally found in minor amounts in milk. Several studies demonstrate the advantages of consuming milk that has been iodine-fortified. Iodine-fortified milk is recognized as a suitable food source to supply iodine adequacy, particularly during lactation [20].

Vitamins are compounds that function in the body as cofactors. Dairy products that have undergone fermentation can be regarded as vitamin sources. Additionally, because some starters can synthesize vitamin B, which is essential for their growth, fermented milk products have varying vitamin contents. The amount of vitamins in the fermented milk product is altered by processes including temperature, incubation duration, heat treatment, and storage conditions. 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. To boost the stability of these vitamins, numerous coating technologies, including microencapsulation, have been developed [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 rickets in children. In addition, vitamin D3 deficiency increases the risk of diseases such as hypertension, infectious diseases, and cancer. Sunlight is the main source of vitamin D3 for people. In the absence of sunlight, vitamin D3 supplements in foods are crucial. Because of this, milk that has been fortified with vitamin D3 is increasingly being used to make cheese [25].

- 3. 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. For foods whose energy value has been decreased by at least 25% from the original product, the term "reduced energy" is utilized from these definitions. In addition, foods with fewer than 3 grams of fat per 100 grams of low-fat solid food or 1.5 grams per 100 mL of liquid food, as well as foods with less than 0.5 grams of sugar per 100 grams



of non-sugar solid food or 100 mL of liquid food, are also used [26]. By decreasing the ratio of saturated fatty acids and increasing the amount of fatty acids that are better for humans to consume, such as  $\omega$ -3 polyunsaturated fatty acids (PUFAs), the composition of milk fat in dairy products can be altered [24]. Light milk, yogurt, cheese, and kefir are produced, which are prepared by reducing and replacing fat. In this way, the energies of the products are reduced, and their rheology is controlled [18].

Functional dairy products are often supplemented with plant sterols in various nations. 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 high 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. A lack of it can also lead to issues like visual disturbances, memory loss, depression, and schizophrenia. Docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) are the two most significant Omega-3 fatty acids. Unicellular phytoplankton and seaweeds are the principal producers of these fatty acids [28]. It also accumulates in seafood throughout the food chain [29]. Due to their high consumption rates and favorable storage conditions, dairy products such as fermented milk and yogurt are good choices for Omega-3 dietary supplements [2]. In recent years, it has been crucial to add EPA and DHA to dairy products like cheese, yogurt, and drinking milk in order to enhance their nutritional value as well as introduce new specialty foods to the market. Because dairy products are commonly used in our daily diets, they are stored at low temperatures, have a short shelf life, and are packaged in non-air and light-permeable packages, which makes them suited for EPA and DHA enrichment. The right amount of EPA and DHA to add to each product must be determined in order to avoid adversely influencing the product's sensory and physical qualities. The characteristics of the food being enriched (amount of water and fat, addition of aroma), undesirable fish taste, and oxidation are a few of the variables limiting the amount of fatty acids [29].

Dairy products with reduced sugar are suitable for lactose-intolerant individuals. Lactose intolerance is caused by insufficient lactose resorption in the small intestine due to the lack or decreased activity of  $\beta$ -galactosidase. As a result, the colon's microbiota ferments the undigested lactose, resulting in the production of lactate, methane, and hydrogen, which results in symptoms like bloating, diarrhea, and stomachaches. Due to these negative effects, lactose-intolerant consumers cannot consume milk or foods containing lactose [30]. In recent years, the consumption of LF-UHT (lactose-free UHT) milk has increased in many countries. Approximately 70% of the world's population suffers from varying degrees of lactase deficiency (hypolactasia). LF-UHT milk is more susceptible to spoilage than normal UHT milk. This is because LF-UHT milk contains a high concentration of reducing monosaccharides. Monosaccharides are more reactive than lactose, participating in the Maillard reaction during the storage and heating of milk. During LF-UHT milk production, the formation of prebiotic galactooligosaccharides (GOS) can occur through transglycosylation reactions [31]. Today, a wide variety of lactose-free dairy products are produced using lactase processing technology, and lactose concentrations are below 0.1% [32]. In dairy products, lactose is reduced by the controlled action of purified  $\beta$ -galactosidases. In the applied lactose hydrolysis technique, lactase is added to the milk to be processed [2]. Since starter bacteria convert lactose into

lactic acid during the early stages of cheese ripening, most cheeses are inherently lactose-free or contain extremely small amounts of it [32].

- 4. 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 enhancement, and texture [33]. Sodium in processed foods is a major public health problem because it leads to the development of hypertension, which may be a precursor to illnesses such as cardiovascular disease in some people [34]. In addition, excessive salt consumption causes a variety of health problems, including kidney stones and stomach cancer, and has a detrimental impact on calcium absorption in human metabolism, which may negatively impact bone health [35]. In addition to these negative consequences, concerns regarding the relationship between dietary sodium and cardiovascular disease have led to a reduction in salt in processed foods [36]. Today, studies are being conducted 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. Between 4-6% in brine cheeses and 0.5-0.7% in acid curd cheeses, the salt concentration in cheeses varies. In order to maintain the safety and shelf life of products like cheese when salt levels are decreased, protective agents may be added. Salt prevents the growth of pathogens and controls harmful microorganisms [33]. Salt helps cheese producers control key cheese parameters such as final moisture content, microbial activity, starter bacteria survival, and enzymatic activity. These factors make it challenging to lower the salt content of cheese. The salt level of cheese also has a direct effect on its flavor and texture. However, low-sodium cheeses frequently have an acidic flavor as a result of excessive acid generation during manufacturing due to the starter culture activity that is aided by low moisture-salt levels during the first stage of ripening [36]. Mineral salt modifiers can be added to maintain enzymatic and microbial stability by protecting the water activity ( $a_w$ ) of the cheese. However, salt modifiers can alter aroma by causing unwanted tastes such as bitterness and metallicity, and flavor enhancers can be employed to inhibit these tastes [34].

- 5. Functional Properties and Food Supplements in Dairy Products from which Phenylalanine Amino Acid is Removed:** Phenylketonuria (PKU), a metabolic disorder that is present at birth, is caused by a lack of the enzyme phenylalanine hydroxylase (PAH) [37]. In other words, PKU is an autosomal recessive metabolic disorder that occurs due to the insufficiency of the PAH enzyme, which converts the amino acid phenylalanine to the amino acid tyrosine, or its cofactor. An increase in the amount of phenylalanine, an essential amino acid, in the blood causes central nervous system damage and, as a result, cognitive disorders [38]. To prevent the brain damage caused by this disease, the level of phenylalanine in the body must be reduced. As a result, there are commercially available products made for patients with phenylketonuria, and laboratory studies are also being conducted in the direction of the development of new products [39]. Foods allowed in the PKU diet are low in protein and should not exceed the recommended phenylalanine limit (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 effective in preventing mental disability in PKU patients, it has problems with taste and nutritional deficits, particularly vitamins B12 and D [41]. Foods for phenylketonuria patients can be categorized 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 high protein content and is a good source of protein hydrolyzate. However, due to their high phenylalanine content, casein and whey proteins must be hydrolyzed and then removed from the environment to release aromatic amino acids [38].

In recent years, the use of glycomacropeptides (GMP) and large neutral amino acids (LNAA) in dietary therapy has been investigated. LNAAs, tryptophan, tyrosine, Phe, and branched-chain amino acids all use the same amino acid transport system across the blood-brain barrier. Tyrosine and tryptophan supplementation has improved serotonin and dopamine metabolism in PKU patients, although this is only appropriate for people who cannot adhere to a low Phe diet [41]. A low phenylalanine whey protein alternative known as glycomacroprotein (GMP) has been developed [40]. Glycomacropeptide (GMP), a glycolysate of 64 amino acids, is a naturally occurring source of protein [42]. GMP is a protein obtained from whey that is naturally low in Phe but high in threonine, valine, and isoleucine [41]. It is found in the whey protein of cow's milk. Fresh cheese has a GMP content of about 25% in its whey protein. GMP is used safely in these patients because it does not contain phenylalanine. Milkshakes and fruit pudding are examples of foods and beverages that include GMP [42]. Short-term studies on people and animals showed that glycomacro protein makes L-amino acids break downless, is absorbed more slowly, and helps the body take in more protein than amino acids without Phe [40]. In addition, studies have indicated that phenylketonuria patients prefer foods containing glycomacroprotein over standard amino acid formulas and prefer a glycomacroprotein-fortified diet [41].

### III. CONCLUSION

Milk and dairy products are important parts of the diet. As a result, it is possible of obtain the necessary nutrients by increasing the functional properties of these products. Increasing the functionality of milk and dairy products has significant commercial and nutritional effects. Dairy products containing probiotics constitute the most important group of functional dairy products. Studies on synbiotics show that probiotic and prebiotic combinations have a greater favorable impact on human health. In addition to this, functional dairy products can be produced with minerals, vitamins, Omega-3 polyunsaturated fatty acids, and other supplements. For the nutrition of patients with particular disorders, functional dairy products are also produced with reduced energy, sodium, lactose, or phenylalanine amino acids. As a result of the food supplements developed for these products, research into the development of new milk and dairy products with higher nutritional value and better organoleptic and quality properties continues. The most crucial reason for consuming functional milk and other dairy products that have been fortified is to raise consumer awareness and the number of pertinent scientific studies.

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