Chapter

Perspective Chapter: Beyond Delicious – The Hidden Functional Benefits of Cheese

Zoha Sohail, Noohela Khan, Mnahil Moazzam, Sania Mujahid, Ayesha Tariq Sindhu, Hamala Khan, Nawa Sohail, Malja Afzal, Aleena, Ayesha Zaheer and Izwa Ishaq

Abstract

Cheese; a diverse and healthy milkproduct with a long history that stretches back thousands of years. It is available worldwide in varying forms and is valued for its delicious taste and superior nutritional content. Classification of cheese is dependent on texture or moisture content, method of coagulation or coagulating agent, maturation or ripening, type of milk and manufacturing techniques. Cheese is comprised of macronutrients, micronutrients and functional nutrients; major macronutrients in cheese are proteins and fats, major micronutrients in cheese include vitamins and minerals and functional nutrients in cheese include cheese bioactive peptides, polyphenols, probiotic, prebiotic, conjugated linoleic acid, sphingolipids, phytanic acid, lactoferrin, γ aminobutyric acid and organic acids. Other than its great taste and flavor cheese is responsible for providing many health benefits i.e. gut protecting activity, antioxidative activity, anticariogenic activity, antihypertensive, antihyperglycemic, cardioprotective and osteoprotective activity to the body. This chapter will focus on the classification, nutritional composition and health benefits of cheese.

Keywords: cheese, nutritional content, macronutrient, macronutrient, health benefits

1. Introduction

Cheese is a soft solid mass of milk comprised of water, protein, fatty acids, minerals, and vitamins. It is considered a high-quality product due to its high biological value and nutritional composition, produced via fermentation, coagulation, separation, and maturation of milk components [1, 2]. Around 8000 years ago, during the agricultural revolution, cheese first developed in the areas of Iraq between the Euphrates River and Tigris known as the Fertile Crescent. Since Mesopotamian times, cheese production has played a significant role in the history of humans due to the domestication of various plants and animals as a source of food. Milk from several

domesticated animals such as goats, sheep, and cattle was used as a growing medium for bacteria to produce different milk products such as cultured milk, yogurt, and cheese [3–5].

Despite the decrease in per capita consumption of dairy items, cheese consumption remains high throughout the world. It is projected that by 2032, the global processing of milk into various milk products, especially cheese, is to increase by 30%. European Union, United States, and New Zealand are expected to be the major exporters of cheese that will fulfill around 65% of the cheese demand globally. However, Saudi Arabia, Russia, Japan, and the United Kingdom are forecasted as the main importers by 2032 [6].

The nutritional composition of cheese is influenced by numerous factors including animal, breed, stage of lactation, and fat content in the milk. It is a nutrient-rich product; abundant in casein, fatty acids, fat-soluble vitamins, and minerals that are retained in curd during processing [2]. The widespread acceptance of cheese is attributed to several factors i.e. nutritional composition, health benefits, variety, and compatibility [7].

Owing to the recent increasing trends of functional foods, cheese manufacturers are exploring the possibility of using cheese as a functional food and have also produced reduced-fat cheese as a result [7]. Food biotechnology has played a significant role in the cheese industry, leading to the development of a wide range of cheese. Besides the fact that cheese was discovered unintentionally, it is regarded as an exceptional product that possesses various health benefits [3].

2. Classification & types of cheeses

Cheese is a concentrated form of milk that has been manufactured and used by humans since the dawn of civilization. Till now, there are more than 1500 different variants of cheese that have been discovered and each variety possesses unique properties [8]. There are no specific criteria for the classification of cheese. However, some integrated approaches have opted to represent the varieties of cheese.

Types of cheese are classified on the basis of [9, 10]:

- Texture or moisture content
- Method of coagulation or coagulating agent
- Maturation or ripening
- Type of milk
- Manufacturing techniques

2.1 Classification based on texture or moisture content

Classification of cheese based on texture primarily relies on the total moisture content. Moreover, moisture level directly imparts the firmness or texture of cheese as higher water content results in a softer texture. **Table 1** represents the categories of cheese based on moisture content [8, 10–12].

Category	Moisture	Example
Very Hard Cheese	<25%	Grana Padano and Parmigiano Reggiano
Hard Cheese	25–35%	Cheddar, Cheshire, Gloucester, Cantal, and Leyden
Semi-Soft/Semi-Hard Cheese	36–40%	Colby, Monterey, Lancashire, and Wensleydale
Soft Cheese	>40%	Cottage, Mozzarella, Brie, and Camembert

Table 1.
Classification of cheese based on texture or moisture content.

2.2 Classification based on the method of coagulation or coagulating agent

Coagulation of milk means the conversion of liquid milk into a semi-solid mass or coagulum. Different coagulating agents/methods including enzymes, acid, heat/acid, and concentration/crystallization can be used for milk coagulation [8, 10, 13, 14].

2.2.1 Enzymatic coagulation

Enzymatic coagulation of milk is the most preferable method adopted by cheese manufacturers for cheese production. This process involves a proteolytic enzyme known as chymosin or renin, which is synthesized by the chief cells of the stomach. Previously, it was extracted from the dried stomach of milk-fed calves. However, due to the advancement in the field of biotechnology, a genetically engineered product rennet is developed. Rennet coagulated cheeses are the most abundantly produced as they account for more than 75% of total cheese production, and they also incorporate all the ripened cheeses. The production of rennet-coagulated cheese is divided into two stages (**Figure 1**). The first stage involves the conversion of milk particles into para-casein micelles. In the second stage, micelles aggregate in the presence of calcium ions and at a temperature of >20°C to form a gel-like structure (coagulum). Parmesan, gouda, and cheddar are some examples of rennet-coagulated cheeses [11, 15, 16].

2.2.2 Acid coagulation

The isoelectric pH for the milk to curd is 4.6 and it is achievable by adding acids such as vinegar (acetic acid) and lemon juice (citric acid) to the milk. Acid triggers the partial unfolding of casein molecules and creates a mesh-like structure by interlinking. These interconnected micelles transform the milk into a semisolid state. Acid-coagulated cheeses like cottage, quarg, cream cheese, and some types of Queso Blanco account for more than 25% of the total cheese produced. Acid-coagulated cheeses are usually consumed fresh because of high contain high moisture content [10, 16–18].

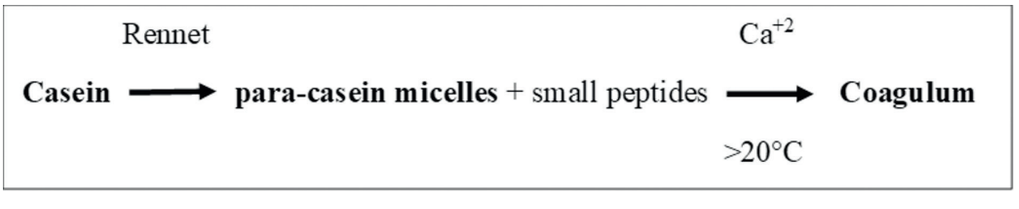

Figure 1.
Stages of rennet coagulated cheese production.

2.2.3 Heat/acid coagulation

Milk can coagulate at pH > 4.6, but this requires an elevated temperature of >80°C. Before the addition of acid, milk is boiled to obtain soft curds such as ricotta, mascarpone, and impastata. Heat/acid-coagulated cheeses are mostly a mixture of whey and milk but can also be made by using whey solely [10, 16, 19].

2.2.4 Concentration/crystallization

The concentration/crystallization method of coagulation is used to produce whey cheese by crystallizing lactose and concentrating the whey. Whey cheese like mysost, mysusostur, brunost, mesost, myseost, and braunkäse exhibit a smooth, creamy texture and a luscious caramel-like flavor. Such cheeses are predominantly prepared in northern European countries like Germany, Norway, Sweden, Iceland, and Denmark [8, 10].

2.3 Classification based on maturation or ripening

Maturation or ripening is a complicated procedure that can enhance the sensory properties of cheese, it involves various metabolic, biochemical, and microbial changes. Primary changes involve processes like proteolysis, glycolysis and lipolysis, and glycolysis. Whereas secondary changes include catalytic activities such as decarboxylation, esterification, amino acid desulfurization, deamination, and fatty acid oxidation. These changes are influenced by several factors including coagulating agents, enzymes (lipases and proteinases), starter and non-starter cultures and their enzymes, and secondary microbial cultures and their enzymes. Numerous factors including the type of cheese, moisture level, and the desired flavor determine the duration of ripening ranging from weeks to years. However, the ripening process can be accelerated by genetically modifying the starter culture, increasing the concentration of the enzymes, and elevating the temperature and pressure of the system [10, 16, 20–22].

2.4 Classification based on milk type

Milk is a lacteal secretion that varies in composition from one species to another. However, the main components such as carbohydrates, proteins, water, fats, vitamins, and minerals remain consistent. The variation in nutrient composition among the milk of distinct species contributes to unique flavors, textures, and aromas in cheese [10, 13, 23]. Milk with elevated total solids and casein levels with a smaller casein micelles size and the BB variant of kappa-casein exhibit better cheese quality [24]. The preferable milk sources for cheese production include cattle, buffalo, goats, and sheep [25].

2.4.1 Cattle milk

The cheese industry predominantly relies on cow milk accounting for more than 85% [10, 26]. The nutrient composition of cattle milk represents that it contains 3.7% fat, 3.4% protein, 4.8% lactose, and 0.4% ash (minerals and vitamins). Additionally, it yields a flavor-dense and creamy-textured cheese. A wide range of cheeses is produced from cow milk ranging from soft to extra hard and not ripened varieties.

Cheeses like Cheddar, Brie, Feta, Mozzarella, and Gouda are prepared by rennet coagulation of heat-treated cattle milk [23, 27].

2.4.2 Buffalo milk

Unlike cattle milk, buffalo milk has a high protein and fat content, 4.7% and 6.7%, respectively. However, both contain similar levels of ash (0.8%) and lactose (4.8%). It also has an enhanced casein-to-protein ratio and calcium content than other varieties. Buffalo milk cheeses such as Mozzarella di bufala and Campana represent about 11% of the total cheese production. Italian cuisine frequently uses buffalo milk cheese, especially in dishes such as caprese salad, pizza, and pasta. Owing to the savory flavor and creamy texture, buffalo milk cheeses are more expensive than others [10, 23, 26, 28].

2.4.3 Goat milk

Since ancient times, goat milk has been used to prepare cheese. The nutrition profile of goat milk reveals that it contains 4.5% fat, 2.9% protein, 4.1% lactose, and 0.8% minerals and vitamin content. Goat milk cheese like Chevre, Feta, and Bûcheron has a soft and creamy texture because of its high moisture content (more than 70%). Additionally, such cheeses feature a distinctive flavor featuring earthy, nutty, and mildly sweet characteristics. Goat milk cheeses are rich in calcium, easy to digest, and do not require a long maturation duration. Besides this, cheeses made from goat milk account for only 2% of all production [10, 23, 26, 27].

2.4.4 Sheep milk

Sheep milk has higher consistency than goat and cow milk because of its high-fat content (~7.4%). Furthermore, it is more nutrient-dense than other milk varieties, comprising 4.5% protein, 4.8% lactose, and 1.0% ash. Cheese made from sheep milk represents only 2% of the total cheese manufactured. Goat milk cheeses have a distinct flavor and rich, creamy texture. Owing to the low moisture content, the coagulum is firm leading to rapid synesis and a slower diffusion of sodium chloride. Feta, Roquefort, and Pecorino are among the well-known varieties of sheep milk cheeses [10, 23].

2.4.5 Mixed milk

Cheeses made from a combination of milk from various species are known as mixed milk cheeses. The nutrient composition, flavor, and texture of cheese vary with the type of milk. Notable varieties include Ossau-Iraty Valdeon and Gorgonzola. Ossau-Iraty and Gorgonzola comprise cow and sheep milk, and Valdeon is a cow and goat milk cheese [10, 13].

2.5 Classification based on the manufacturing techniques

Cheese making is a complex process involving the selection, pretreatment, standardization, acidification, and coagulation of milk, dehydration of coagulum, and the shaping along with salting of cheese curds. Moreover, some varieties necessitate the maturation/ripening of cheese as an additional step. Dehydration is a prime step in

the cheese manufacturing process as it concentrates the milk and enhances the shelf life of the cheese. Numerous factors, including milk type, pH, cultures, moisture, and salt concentration, generate distinct flavors and textures of cheese. These distinctive characteristics primarily enhance during ripening/maturation. Therefore, manufacturing steps largely influence the nature and quality of the final cheese product and result in the emergence of a new classification system [3–5, 13, 29, 30]. Cheeses with different manufacturing techniques are as follows:

2.5.1 Brined cheese

Brined cheeses also referred to as pickled cheeses, are those that mature in brine water. Ripening in brine solution preserves the cheese by reducing the moisture content. A high concentration of salt enhances microbial stability by increasing the osmotic pressure. The texture of pickled cheeses like Feta and Domiati varies from semi-hard to soft. Fresh brined cheeses have an acidic and salty flavor and develop a piquant flavor upon ripening. During the maturation process, the cheese is immersed in a 14% salt (NaCl) solution and allowed to mature for a minimum of seven days at a temperature of 14–16°C. Once the pH level drops to 4.5, it is stored for at least two months, at a temperature of 3–4°C [14, 31].

2.5.2 Surface-ripened cheese

Surface-ripened cheeses are a diverse class characterized by the development of microbial or fungal growth during ripening. These cheeses are further categorized based on microbial growth as smear-ripened or washed-rind and mold-ripened cheeses. The distinctive characteristics of surface-ripened cheeses rely on the microbial (bacteria or fungal) growth on the surface of the cheese.

Smear-ripened cheeses like Brick, Beaufort, Comté, Italico, and Butterkase develop a thick layer of bacterial growth on the surface during maturation after washing with a salt solution. These are also known as bacterial surface-ripened or red-smear cheeses because of the red smear. *Brevibacterium linens, Brevibacterium aurantiacum Arthrobacter arilaitensis, Arthrobacter bergerei, Agrococcus casei, Microbacterium gubbeenense, Staphylococcus succinus* subspecies *Casei, Staphylococcus equorum* subspecies *linens*, and lastly *Corynebacterium casei* are a few well known bacterial species involved in the production of smear-ripened cheese.

Mold-ripened cheeses like Camembert and Brie develop a layer of fungi. Such cheeses create a compound ecosystem consisting of filamentous, acid, and salt-tolerant species of fungi such as *Debaroymces hansenii, Geotrichum candidum,* and *Penicillium camemberti).* Furthermore, mold-ripened cheeses have a soft texture [10, 14, 32–34].

2.5.3 Blue cheese

Blue cheeses or blue-vined cheeses belong to the non-surface ripened cheeses. Inculcation of *Penicillium Roquefort* (a fungus) in milk creates unique blue vines varying from whitish and pale green to dark blue-green. The aging of cheeses encourages the mold to grow under specific humidity and temperature conditions. Blue cheeses have a soft texture and a piquant flavor due to the n-methyl ketones produced by extensive lipolysis. Some well-known types of blue cheese include Bleu d'Auvergne, Cabrales, Gorgonzola, Danablu (Danish Blue), and Stilton, and Roquefort [10, 14, 35–37].

2.5.4 Nutritional composition of cheese

In addition to its delicious flavors and textures, cheese is a fantastic dairy product with exceptional nutritional makeup. Understanding cheese's potential as a food with considerable health benefits requires a thorough comprehension of its nutritional composition. Cheese is a prime example of the nutritional power of dairy products, because of its high protein content, different fat content ranges, and a wide variety of crucial vitamins and minerals. Understanding cheese's macronutrient and micronutrient makeup reveals the breadth of its nutritional value and emphasizes the importance of cheese as an important part of a balanced diet. By delving into the nutritional details of cheese, cheese also provides many functional nutrients important for human health [38, 39].

2.6 Macronutrients

2.6.1 Proteins

Cheese is a great source of high-quality proteins providing many physiological functions and contains all the essential amino acids except methionine and cysteine. [38]. Major proteins present in cheese include casein 97–98% and 2–3% whey. The digestibility of proteins in cheese is increased with the ripening of cheese because as the cheese ages the casein in protein is further broken into free amino acids and water soluble peptides. The high amino acid content in cheese promotes human growth and development. As the protein from cheese gets bioavailable to the body it provides anti-antibacterial, antioxidative, antihypertensive, antithrombotic, cholesterol lowering, and immune-modulating activities [39].

2.6.2 Fat

The fat content of cheese varies between 20 and 35% of its dry mass, of which 66% are saturated fatty acids (SFA), 30% are monounsaturated fatty acids (MUFA), and 4% are polyunsaturated fatty acids (PUFA) including omega-3 and omega-6 fatty acids. The fat content of cheese is dependent on the type of cheese, animal nutrition, manufacturing processes, and some other factors [40, 41]. Oleic acid is the most prevalent unsaturated fatty acid found in milk fat. The concentration of Tran's fatty acids in cheese is varied as per the season. In comparison to winter, the cheese composition in the summer is lower in saturated fatty acids (SFA), and higher in cis-monounsaturated fatty acids (MUFA) and total trans fatty acids. Trans-18:1 and – 18:2 isomers exhibit seasonal fluctuation as well [42]. Cheese's flavor, texture, and nutritional value are all influenced by these fatty acids.

Fatty acids in cheese also provide many health benefits i.e. saturated fatty acids have a variety of physiological functions and are crucial for controlling cell functioning, gene expression, genetic regulation, PUFA bioavailability, and fat synthesis [39]. However unsaturated fatty acids present in cheese support the health of the brain, heart, and eye, as well as promote anti-inflammatory properties. Particularly among unsaturated fatty acids; omega-3 fatty acids have been linked to brain and cardiovascular health [43].

2.6.3 Carbohydrate

Cheese contains carbohydrates in the form of lactose; as it ripens most cheese varieties become lactose-free, advantageous for individuals with lactose intolerance.

People on low-carb or ketogenic diets benefit from its low carbohydrate content and low glycemic index, which helps to regulate blood glucose levels. [39, 44, 45].

2.7 Micronutrients

2.7.1 Minerals

An abundant quantity of calcium is present in cheese in the form of colloidal calcium phosphate (CCP) which is essential for healthy bones, adequate neuron functioning, and muscular contraction. The concentration of calcium in cheese is varied on the basis of the type of cheese, the manufacturing process, and the aging of cheese. As compared to soft and fresh varieties of cheese, hard and aged cheeses usually have greater calcium content. Hard cheese contains around 800 mg of calcium per 100 grams. Due to the acidification of the milk in the containers, soft cheese has a lower calcium concentration than semi-hard and hard cheeses [38, 46]. Absorption of calcium in the body is affected by various factors i.e. pH, calcium-binding proteins, and interactions with other nutrients in the digestive system [39, 47]. In addition to calcium, cheese is also a good source of phosphorus, magnesium, and zinc, important for overall bone and dental health [7].

2.7.2 Vitamins

The concentration of fat soluble vitamins is dependent on the fat content of the cheese. During cheese processing, the majority of fat-soluble vitamins are retained whereas some water-soluble vitamins are lost as a result of losses in whey. Vitamin A, B2, B12, and B9 are often found in cheese and remain stable after pasteurization and ripening. Hard cheese contains 10% of daily calories, 15% vitamin A, 10% vitamin B2, 20% vitamin B6, and 40% vitamin B12. Although the concentration of vitamins in cheese might vary depending on farming practices, nutrition, mastitis, and milk heating [38, 39].

Cheddar cheese has been consumed by many people as a vitamin D substitute. It has been recommended to fortify low-fat cheeses with vitamin A and D to compensate for the loss of these fat soluble vitamins during milkfat separation. Vitamin A and E are present in the form of β- carotenes, α-tocopherol, and γ-tocopherol; aid in providing antioxidant properties and help to regulate normal physiological functions of the body. However, B vitamins in cheese have a number of health advantages i.e. helps in supporting the immune system, aids in managing nervous system health, and helps to regulate energy metabolism [39, 48].

2.7.3 Functional nutrients

In addition to its basic nutritional composition, cheese also contains functional nutrients that offer potential health benefits beyond basic nutrition. These functional nutrients include bioactive compounds (polyphenols), peptides, probiotics, and other components that may positively impact human health.

2.7.4 Cheese bioactive peptides

Cheese bioactive peptides are protein fragments in the form of small amino acid sequences released during the ripening of cheese. Different cheese varieties contain

distinct sets of peptides, contributing to the unique flavors and potential health effects. These bioactive compounds function as antioxidants, and anti-inflammatory agents, and even provide antibacterial properties; aiding the body's defense against potentially dangerous substances. Some cheese peptides have been shown to exhibit Angiotensin converting enzyme (ACE) inhibitory properties, which means they can help control blood pressure by blocking the angiotensin-converting enzyme [41].

2.7.5 Polyphenols

Polyphenols are naturally present in cheese and during the process of cheese making they interact with milk proteins; essential for cheese production and human nutrition. They improve the nutritional value and functionality of cheese i.e. they serve as antioxidative, anticancerous, and anti-inflammatory agents. Polyphenols also aid in the prevention of, cardiovascular disorders, diabetes mellitus, and neurological illnesses [49].

2.7.6 Probiotic

Probiotics are living organisms that work with the objective of immunological, antagonistic, and competitive forces to promote the host's health. The major naturally occurring gut florae are *Bifidobacterium* and *Lactobacilli*, which are intentionally added to milk products like cheese and yogurt during the fermentation process. Important health benefits of these microbes include antimicrobial activity, improved gastrointestinal and immune health, and antimutagenic and anti-carcinogenic activities [50, 51].

2.7.7 Prebiotic

Prebiotics are indigestible carbohydrates that provide sustenance for healthy microbes in the stomach, fostering their development and activity. Some percentage of prebiotics is present in some varieties of cheese i.e. Galactooligosaccharides, synthetic fructooligosaccharides (FOS), oligofructose, inulin, and lactulose. These prebiotics influence physiological and metabolic functions i.e. they help to improve health and decrease the likelihood of various diseases. They serve a significant role in improving renal functional tests, they provide cardiovascular support, manage gastrointestinal health, improve bone mineral density by increasing the absorption of calcium, magnesium, copper, and, zinc and also strengthen the immune system [52].

2.7.8 Conjugated linoleic acid (CLA)

CLA is a fatty acid found in the milk of ruminant animals, it is a class of linoleic acid (C18:2) isomers containing conjugated double bonds. Cheese made from the milk of grass-fed animals may contain higher levels of CLA. It has been associated with several potential health benefits i.e. it helps in reducing high body mass, helps in muscle coordination, and prevents cellular inflammation. CLA's antioxidant activity promotes anti-carcinogenic effects and also helps in reducing the risk of atherosclerosis. It also exhibits antiadipogenic, anti-diabetogenic, and anti-inflammatory effects [41].

2.7.9 Sphingolipids

The second-best source of sphingolipids after soybeans is milk and its products, especially cheese. Sphingolipids are made up of a sphingoid base, a fatty acid, and

numerous head groups providing distinct biological roles. The concentration of sphingolipids in cheese is modified by many factors i.e. animal breed, food, and cheese-making procedures. Sphingomyelin content in cheese per kilogram is 115 mg. Sphingolipids are responsible for providing many health advantages i.e. cardiovascular health support, immune system modulation, prevention against cancer, and helps in proper brain functioning [39].

2.7.10 Phytanic acid

Another important functional nutrient present in cheese is Phytanic acid; (C20) fatty acid. Phytanic acid is a C20 saturated fatty acid with four methyl branches which has been documented to provide anti-carcinogenic properties, improve glucose homeostasis and increase hepatocyte glucose absorption [41].

2.7.11 Lactoferrin

Lactoferrin is a glycoprotein present in milk and dairy products. It yields microbicidal peptides such as lactoferricin and lactoferrampin. Lactoferrin is beneficial for the human body i.e. it possesses antibacterial, immune modulating, and anti-inflammatory properties [53].

2.7.12 γ aminobutyric acid

γ aminobutyric acid (GABA) is a 4-carbon nonprotein amino acid; produced during the fermentation process during cheese making. The total content of GABA in cheese is dependent on the kind of cheese, ripening stage, amount of protein, natural microbiota, and activity of proteolytic enzymes. All cheeses contain a certain amount of GABA but commercial French cheeses contain great concentrations. GABA in the human body works as an antihypertensive, immunomodulatory, antidiuretic, and tranquilizing agent. GABA can manage diabetes mellitus, treat depression, and alcoholism, control pain, prevent anxiety, and boost the concentration of growth hormones [41].

2.7.13 Organic acids

Organic acids are naturally occurring compounds that form during the fermentation and aging process of cheese, providing distinct flavor and a variety of health benefits. Organic acids produced during cheese fermentation and processing include lactic acid, acetic acid, butyric acid, propionic acid, and hippuric acid. These acids serve many health benefits i.e. they serve as antibacterial, anti-inflammatory, and gut-producing healthy bacteria [41].

2.8 Health aspects

Cheese is a fermented dairy product that contains beneficial microorganisms and health promoting components that help to maintain a good nutritional status [54].

2.8.1 Gut protective activity

Chief microorganisms found in cheese include Probiotic *Lactobacillus spp.* and *Bifidobacterium spp*. These microorganisms help in forming healthy gut microbiota

and are thus beneficial in suppressing the growth of harmful bacteria. According to a study published in the Journal of Applied Microbiology, Cheese contains particular probiotic strains that help to form short-chain fatty acids which are beneficial for gut health. The presence of probiotic strains in cottage cheese leads to excellent probiotic microbe survival, forms good metabolic behavior, and also leads to the production of potential antioxidant peptides and antilisterial substances in the gastrointestinal tract [55].

Fortification of cheese with *L. helveticus SBT2171*; a microorganism that helps in regulating T cells (Treg) and also prevents in controlling & preventing inflammatory response against IL-17, IL-4, and IL-10 production in gut Peyer's patch cells in healthy mice. This fortified cheese also helped in improving colitis symptoms in rats with Dextraran Sulphate Sodium-induced colitis. Fortification of Italian hard cheeses with *L. helveticus R0389* leads to the reduction of intestinal epithelial cell chemokine production [56].

2.8.2 Anti-oxidative activity

Cheese contains sulfur amino acids, whey proteins (especially -lactoglobulin), vitamins A, E, and C, and -carotene all of these contribute to the antioxidative activity. Fermentation and cheese maturation is linked to the formation of bioactive peptides, which are responsible for enhancing antioxidative properties. The use of probiotic strains significantly boosts antioxidant levels. Antioxidants in cheese can scavenge superoxide, hydroxyl, and peroxide radicals, as well as reactive oxygen species. Cheese fermented with *Lactobacillus acidophilus* has significantly improved antioxidant activity. Cheeses are fortified with *L. acidophilus 2499;* a microorganism that contains a good percentage of L-carnosine and anserine [57, 58]. L-carnosine has a role in chelating metal ions and possesses antiglycating, antioxidative, and anti-crosslinking characteristics. Carnosine plays a great role in muscular health and has a role in preventing neurodegenerative illnesses [59].

2.8.3 Anti-cariogenic activity

Cheese contains an abundant amount of calcium, and plays an important role in increasing the pH of the oral cavity thus preventing the process of demineralization. Other than calcium, *Casein*; an anti-cariogenic phosphoprotein found in cheese creates a protective layer on the tooth enamel decelerating the process of caries development [60]. Consumption of cheese after the consumption of fermentable carbohydrates prevents the decline in pH and promotes anticariogenic activity [61]. Cheese has a pH that is near neutral or slightly alkaline, which helps to balance the acidic conditions in the mouth. Its high calcium and phosphorus content contributes to the cariostatic mechanism. Cheese also helps in reducing radiation caries caused by head and neck cancers. According to certain research, consumption of cheese among both non-irradiated and irradiated people showed surface enamel rehardening; promoting saliva production through mastication [62, 63].

2.8.4 Antihypertensive activity

Cheese contains two well-known antihypertensive bioactive peptides i.e. *VPP (Val-Pro-Pro)* and *IPP (Ile-Pro-Pro)* present in a variety of cheeses (Gouda, Domiati, and Edam) [64]. Other than these bioactive peptides cheese also contains

(RPKHPIKHQ9, YPFPGPI) which plays a role as an antihypertensive agent and as an Angiotensin Converting Enzyme (ACE)-inhibitor [65]. In another study, a decrease in total cholesterol and low-density lipoprotein was seen after three weeks of following a hypocaloric diet accompanied by probiotic cheese containing *L. plantarum TENSIA*; a microorganism. This probiotic cheese has great potential for decreasing metabolic syndrome symptoms and arterial blood pressure [66]. Cheddar cheese fortified with *Lactobacillus casei 279*, *Lactobacillus casei LAFTI L26, Lactobacillus acidophilus LAFTI L10, Lactobacillus rhamnosus 6134,* and *Lactococcus lactis* showed enhanced bioactivity for ACE inhibition and high blood pressure control [67].

2.8.5 Anti-cancerous activity

Cheese made from the milk of ruminant animals such as cow and sheep contains a fatty acid known as *conjugated linoleic acid* [49] and possess anti-carcinogenic qualities. Contents found in CLA are *cis*-9, *trans*-11 CLA, and *trans*-11 C18:1 all are responsible to suppress cancer cell development and are responsible to promote malignant cell death. CLA has been found to prevent a variety of health conditions responsible for causing cancer i.e. obesity, inflammation, atherogenicity, and immunomodulation [68, 69]. CLA suppresses the growth of human malignant melanoma and colorectal cancer cells and is cytotoxic to MCF-7 cells; causing breast adenocarcinoma [70].

Cheese is high in calcium, which has been linked to lower the risk of colon cancer. Some studies have shown that consuming more calcium, notably from dairy products like cheese, may protect against the development of colorectal adenomas and colorectal cancer [71]. *Lactobacillus plantarum Lb41*; a microorganism has been used in the fortification of cheese as it possesses anticancer properties [72].

2.8.6 Anti-hyperglycemic activity

Cheese is very much beneficial in maintaining high blood sugar levels due to the presence of fats proteins, calcium, and bioactive peptides. Proteins have a role in delaying carbohydrate digestion thus slowing the surge in blood sugar level. Fats slow digestion and also help to bind carbohydrates, thus preventing them from being absorbed rapidly into the bloodstream. Calcium keeps the body's cells open to insulin and thus prevents insulin resistance and enhances insulin sensitivity [73]. Bioactive compounds present in cheese (di-peptidyl-peptidase-IV, DPP-IV) have a role in preventing the development of diabetes mellitus [74].

2.8.7 Cardioprotective activity

Cardiovascular Disease (CVD) is a broad term that includes a variety of conditions such as heart failure, atherosclerosis, cerebrovascular disease, peripheral vascular disease, and other cardiac abnormalities. Bioactive compounds i.e. *VPP* and *IPP* are the most prevalent cardio-protective peptides found in hard cheese and provide cardio protective activities i.e. ACE inhibitory action. The primary isomer of CLA found in cheese is *Cis9 trans11 C18:2* [49]. It is responsible for anti-atherosclerotic, antioxidative, and anti-inflammatory activities. Isolation of oleic acid [cis9trans11 C18:2 [49]] from hard cheeses and blue cheeses had shown to have cardio protective properties [75, 76]. Cheese has a high concentration of vitamin K2; which functions in lowering vascular calcification [77].

2.8.8 Osteoprotective activity

Cheese is a good source of calcium, vitamin D, and proteins; all of these are the three primary nutrients that govern bone structure and maintenance. Bone growth and development is a very major concern in infancy and adolescence; its consumption should be according to the recommendations in these lifespans for healthy bone development. Parmesan cheese a type of cheese is a "functional food" for bone health and osteoporosis prevention because it includes high biological value protein and calcium that is easily accessible [78]. Phosphate is essential for the mineralization of cartilage and osteoid tissue, found in high concentrations in protein-rich foods such as Swiss cheese (500 mg/100 g). Calcium obtained from cheese has a role in enhancing bone mass more than calcium tablets. The mass of cortical bone tissue has been raised by cheese consumption because of its high calcium content. According to the study, consumption of 20 g of cheese have a role in lowering the risk of hip fractures in both men and women by 10–15% [79].

Certain cheeses, such as Gouda and Brie, contains vitamin K2, a type of vitamin K. Vitamin K2 is associated with improved bone health because it improves calcium metabolism and directs calcium to the bones rather than soft tissues [80]. Vitamin K is also required as a cofactor in the carboxylation of glutamic acid important to control vascular calcification and bone metabolism [81].

3. Conclusion

Cheese is a premium food product manufactured from fermented milk that is rich in proteins, vitamins, minerals, and milk fat. It is made through whey separation, maturation, and the coagulation of milk proteins. Since ancient civilizations, cheese has been a common dietary item. Its nutritional benefit is related to the healthy milk components that it contains. There are over 1500 kinds of cheese that are well recognized, each with its distinct characteristics. Cheese has a protein content that ranges from 4–40%, making it a rich source of high-quality proteins. Its fat content ranges from 20 to 35% of its dry mass, with the summer months having greater levels of fatty acids than the rest of the year. Cheese is advantageous for lactose-intolerant people and those following low-carb or ketogenic diets because it ripens by partly eliminating lactose with whey and fermenting the remaining lactose to form lactic acid and other compounds. Numerous micronutrients, including as calcium, phosphorus, zinc, magnesium, and vitamins, are present in it. Functional elements including polyphenols, peptides, and probiotics found in cheese enhance human nutrition and calcium absorption. GABA, organic acids, and Lactoferrin all improve flavor and quality. It has a long shelf life, beneficial bacteria, antioxidant and anti-cariogenic effects, and antihypertensive and anti-cancerous characteristics. Overall, cheese is a nutritious and healthful dairy food that supports general health and wellbeing.

Author details

Zoha Sohail[1*], Noohela Khan[2], Mnahil Moazzam[3], Sania Mujahid[4], Ayesha Tariq Sindhu[3], Hamala Khan[5], Nawa Sohail[6], Malja Afzal[7], Aleena[2], Ayesha Zaheer[8] and Izwa Ishaq[9]

1 Fatima Memorial Institute of Allied Health Sciences, Pakistan

2 Riphah International University, Pakistan

3 University of Veterinary and Animal Sciences, Pakistan

4 Rashid Latif Medical College, Pakistan

5 CCL Pharmaceuticals, Pakistan

6 Forman Christian College, Pakistan

7 Akhtar Saeed Medical and Dental College, Pakistan

8 NUR International University, Pakistan

9 University of Lahore, Pakistan

*Address all correspondence to: zoha1sohail@gmail.com

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