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Review Article

Health Promoting Components in Milk and Milk Products

Bikash C. Ghosh* **and Volker Heinz**

German Institute of Food Technology, Professor-von-Klitzing-Strasse 7, 49610 Quakenbruck , Germany

ABSTRACT

Review on health promoting activities of milk fat, protein, lactose, their hydrolysed products, and milk minerals on diseases control and physiological benefits are highlighted. Milk fat and the presence of both saturated and some unsaturated fatty acids including Conjugated Linoleic Acid (CLA) have shown important physiological role including lowers body fat in human and anti-cancerous. Proteins provides basic nutrition including essential & non-essential amino acids and play vital role in muscle functions, immunological health, and their maintenance. It offers several functional benefits in supporting good metabolic and overall health. Proteins have shown positive impact on complications like hypertension, dyslipidaemia, hyperglycaemia, immunoglobulins, and mineral binding features etc. Lactose derivatives (1518%) serve as prebiotics and have shown improved growth of the beneficial microflora in the gut. Ca supplements improve the serum lipoprotein profile, particularly by decreasing serum total and LDL-cholesterol concentrations. Fermented dairy products are protective against type 2 diabetes. Consumption of whole fat dairy is related with lower prevalence of metabolic syndrome with lower incidence of hypertension and diabetes. Whey contributes beneficial attributes of lactose and its derivatives in addition to sulphur containing essential amino acids from whey proteins. More research is required for better understanding the physiological effects and the mechanisms involved in dairy products for the prevention and treatment of health problems.

Keywords: Milk; Bioactive peptides; Milk products; Health benefits; Functional activities

Abbreviations: CLA: Conjugated Linoleic Acid; MetS: Metabolic Syndrome; MCFAs: Medium Chain Fatty Acids; CVD: Cardiovascular Disease; T2D: Type 2 Diabetes; CNH: Casein Hydrolysate; MF: Milk Fat; SFA: Saturated Fatty Acid; MUFA: Monounsaturated Fatty Acid; PUFA: Poly Unsaturated Fatty Acid; CLA: Conjugated Linoleic Acids; BCAAs : Branched Chain Amino Acids; ACE: Angiotensin Converting Enzyme; DPP-IV: Dipeptidyl Peptidase IV; DM: Diabetes Mellitus; AA: Amino Acids; HMG-CoA: 3-Hydroxy-3-Methylglutaryl Coenzyme A; GI: Glycaemic Index; SFA: Saturated Fatty Acids; WPC: Whey Protein Concentrate; WPI: Whey Protein Isolate; RDA: Recommended Daily Allowance; LDL: Low-Density Lipoprotein; HDL: High-Density Lipoprotein; TG: Transglutaminase.

INTRODUCTION

Milk and milk products are the foods which provide overall health benefits to all the population in the world. Relationship between food and health is a complicated issue. Each person needs food to live, but too little food, too much food, or the wrong type of food has negative consequences on health. As a result, different types of diseases occurred and finally caused for death of the population. The details of death due to the diseases are given in the Figure 1. The constituents of milk are healthy besides it is allergic for very small segment of population. It is consumed by all class of population with connotation of vegetarian food for better health throughout world. Milk is a chief source of protein for the large section of India's vegan inhabitants. Besides being a rich source of good quality protein, energy furnishing lactose and fat, it is packed with essential nutrients like calcium, phosphorus, fat soluble vitamins, such as A, D, E, and K and water-soluble vitamins. Vitamin C is only deficient in milk. On an average 100 g of milk provides about 75-100 calories of energy. It contains essential fatty acids and bioactive components that are beneficial in maintaining health and preventing diseases. The nutritional composition of milk makes it an ideal choice for children, adults, pregnant women, and patients as well but, those having milk allergies or lactose intolerances may look out for milk alternatives like fermented milk

***Correspondence to:** Bikash C. Ghosh, Department of Dairy Technology , ICAR- National Dairy Research Institute, Adugodi, Bengaluru-560030, India, E-mail: ghosgoga@hotmail.com

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and milk products.

Milk and milk products are gold mine of nutritional, biochemical, and functional activities of which only a fractional part have been explored. The sumptuous and balanced amount of macro, micro and functional components in milk and milk products possess plenty of life sustaining and health promoting benefits. Cow milk is energy-rich and supplies high-quality protein. It plays an important role to meet the required nutrient intakes of calcium, magnesium, selenium, riboflavin, vitamin B12 and pantothenic acid. The nutritional properties of macro and micro components of milk i.e. milk fat, proteins, lactose, minerals, vitamins, enzymes, pigments etc. have direct linear impact on human health [1]. It can provide a major share of energy and daily dietary requirements for routine sustenance of life as well as the functional properties derived from the macro components in milk and milk products [2]. It furnishes vital health promoting benefits. More than 6 billion population worldwide consume milk and milk products; most of these people live in developing countries.

Globally, milk is one third biggest supplier of protein and one fifth largest provider of energy. Various bioactive peptides derived from milk proteins have established impact on our immune system, in nervous system regulation, improvement in digestive/gastrointestinal and cardiovascular health, antithrombotic, antimicrobial, mineral carrying, anti-cancerous, cholesterol reducing and anti-hypertensive activities etc. Extensive research study suggests that regular consumption of certain dairy products have shown promising impact on controlling, mitigating, and reducing Metabolic Syndrome (MetS) which is defined as an array of health implications such as abdominal obesity, hypertension, hyperglycaemia, dyslipidaemia etc. The health protecting and promoting compounds in milk and milk products which have been at the focus of research are milk proteins, lactose and their fermentation derivatives, lipids, vitamins, and minerals. Milk and milk products contain either of 3 macro components (Fat, Protein and Lactose) in total or partially and many micro components (Vitamins: A, D, E and K, riboflavin, B1 calcium, Phosphorus, Magnesium, zinc etc.). Many studies suggest that eating of ripened/fermented dairy products like cheeses and yoghurt are linked with reduced risk of cardio-metabolic disorders. A study on association of dairy consumption in 21 countries revealed that higher intake of whole fat dairy is related with a lower prevalence of MetS and lower incidence of hypertension and diabetes [3]. In short term consumption whey exhibits insulin tropic properties whereas Medium Chain Fatty Acids (MCFAs) enhanced the insulin sensitivity. Amino acids derived from caseins and whey proteins, MCFAs along with milk minerals like calcium have been found beneficial in body weight and body fat reduction. Peptides, milk minerals (calcium primarily) and live probiotics bacteria in dairy products are found to reduce plasma cholesterol as well as positively regulate blood pressure. Fermented and probiotic cultured milk products have beneficial impact on reducing absorption of cholesterol in the intestine, sphingomyelin derived from cholesterol and fat, bile acids etc. Lactose, the milk sugar apart from its energy furnishing role, it also helps in increasing bioavailability of calcium thus helps in body weight management, bone and teeth health, blood pressure control and improves folate's bioavailability with the help of citrates and milk proteins.

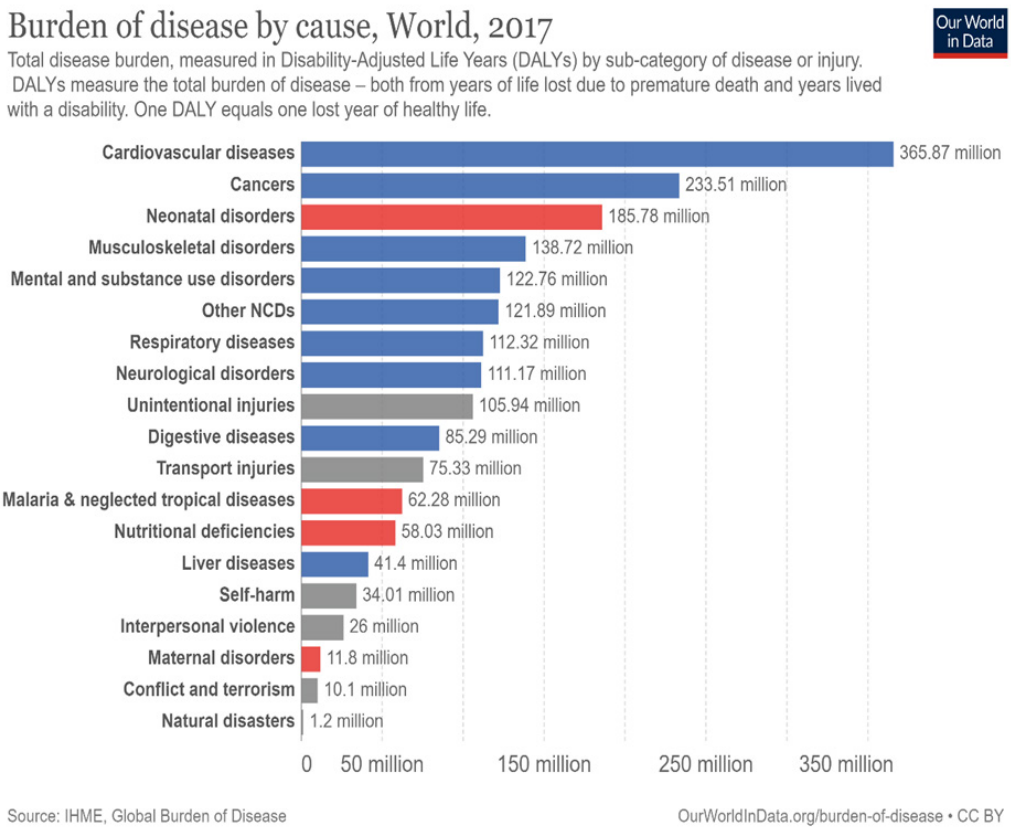

Figure 1: Occurrence of Disease Burden in the world.

RELATION OF MILK COMPOUNDS WITH DISEASES

Milk and milk products have proteins which favour the assimilation besides being of high biological value. The consumption of other elements like fat, carbohydrates, vitamins and minerals, calcium, and phosphorus show some favourable effect on certain chronic diseases. Scientific investigations have reported a beneficial effect of dairy products consumption on plasma lipid levels, especially with full-fat natural cheese and fermented strain-specific yogurt products [4]. Dairy products like cheese, yogurt and cottage cheese, are a satisfactory source of calcium, which support to maintain bone density and reduces the risk of fractures. Relation between milk components and their beneficial effects on major diseases which are causing for death is highlighted below

Milk and cardiovascular health

There is no evidence to indicate the relation that higher intake of dairy products increases Cardio Vascular Disease (CVD) till today. Conversely, the milk fat might be beneficial because of its rumenic and vaccenic acids and the concomitant presence of calcium, whey proteins, and other bioactive molecules. No significant association between saturated fatty acid consumption and increased risk of CVDs has been reported. The consumption of milk and dairy products cannot, as of today, be positively or negatively associated with cardio-metabolic or stroke risk [5].

Milk and cancer

Chemo-preventive properties are existing in milk which can be attributed to its calcium, vitamin D and conjugated linoleic acid contents. A direct relationship between higher intakes of calcium and reduced risks of various cancers including gastrointestinal, colorectal, and ovarian cancer has been reported by National Cancer Institute (2009) [5a]. Calcium has been found to repel cell proliferation, provoke differentiation and apoptosis in the gastrointestinal tract and in the mammalian gland, and bind to fatty acids in the intestine, therefore reduces their harmful effects on the mucosa. It is suggested that people who regularly eat dairy products (particularly milk) have lessen the risk of developing colon cancer (Australian Dietary Guidelines). However, intake of dairy products has no effect to reduce breast cancer. Moderate intake of dairy products may keep you away from cancers. Milk proteins have exhibited an anti-carcinogenic property. Studies indicate that milk proteins may protect against some cancers such as colon, breast, and prostate gland [6].

Milk and blood pressure

Milk consumption has been found to lower blood pressure which is primarily due to the whey proteins. Whey proteins contain bioactive peptides which have angiotensin-converting enzyme–inhibiting activities that control blood pressure. In addition to their activity on blood pressure some of these peptides have putative antithrombotic (casopletelin from k-casein) properties. Besides whey proteins, calcium, potassium, magnesium, and vitamin B contents in milk also contribute to promote lower blood pressure. Bioactive peptides from milk, primarily β-lactoglobulin-derived β-lactostatin is known to produce cholesterol lowering effect by agaitating the stability of cholesterol micelles. Another β-lactoglobulin-derived peptide β lactotensin is also known to possess cholesterol-lowering activity [7]. A meta-analysis of prospective cohort studies suggests that the eating of dairy products is associated with a reduction in the risk of high blood pressure [8].

Milk and diabetes

Consumption of milk and milk products may safeguard against occurrence in developing Type 2 Diabetes (T2D). Many reports have shown the positive effect of milk on diabetes. A systematic review and meta-analysis was done [9]. (2023) suggested that dairy in general and fermented or cultured milk products are protective against T2D while milk, cheese and other dairy products have a neutral effect with no effect on incident of T2D. It is because lactose unlike other sugars do not seem to be linked with diabetes prevalence. Moreover, milk has a relatively low glycaemic index due to its proteins. Casein exhibits insulin genic properties and facilitate glycaemic rule. Administration of Camel milk has shown positive effect on glycaemic control by reducing fasting blood sugar. The fatty acid trans-palmitoleic acid present in the milk has also been found to play important roles in controlling type 2 diabetes *via* its action on insulin secretions. Milk derived bioactive peptides are reported to regulate insulin secretion and help in preventing the occurrence of type 2 diabetes. Both whey protein and casein show insulin tropic properties. Studies have shown the reduction in serum glucose after the uptake of Casein Hydrolysate (CNH). Bioactive peptides from β-casein are known to show Dipeptidyl Peptidase-IV (DPP-IV) inhibitory activity that regulates the glycaemia and provide antidiabetic effect [10]. Whey proteins showed DPP-IV inhibitory activities to reduce the risk of type -2 diabetic occurrences [11].

Milk and osteoporosis/bone health promotion

Milk is a very good source of calcium, which is required for the development and maintenance of bones and teeth health. It supplies more than 70% of RDA of calcium. It also contain Vit D. Together with Vit D and calcium and Phosphorus help in bone formation, strengthening of bones and reduces the risk of osteoporosis. Other nutrients like magnesium, zinc, vitamins A, and K present in milk also contribute to healthy bone development. Removing milk and milk products completely from the diet can lead to an inadequate intake of calcium. This is of concern for those who have high calcium requirements especially elderly women. So milk should be taken not only by young children, but adults need it to keep their bones strong and to prevent osteoporosis.

Milk and depression

Milk can help to fight depression. It can de-stress at the end of a stressful day. This is because milk contains tryptophan, an amino acid which lowers stress and supports to induce sleep curing insomnia. Besides this amino acid, the vitamin D in milk aids in the production of serotonin, a hormone associated with mood, appetite, and sleep. Deficiency of Vitamin D has been linked with depression and chronic fatigue [12]. Milk is fortified with Vitamin D can improve low mood status. A glass of warm milk at night helps to relax tense muscles, soothe frayed nerves, and sound sleep. Intake of vitamin D rich food like milk/vit D fortified milk and fish can improve the depression during the battle of COVID-19 pandemic.

Milk and tooth decay

Milk is a rich source of calcium and phosphorus which are important to maintain better & strong bones and teeth. It also prevents tooth decay and cavity. Drinking vit D fortified milk helps to prevent cavities and tooth decay. Calcium, phosphorus and

casein in milk and dairy products form a protective film on the enamel. This coating prevents teeth from decay caused by bacterial acids. Casein and lactoferrin help to reduce bacterial growth which causes dental caries.

Milk and muscle building

Milk proteins are supportive for muscle growth and repair. Dietary proteins help to rebuild muscles. Consumption of milk intensely supports muscle protein synthesis, leading to an increased muscle protein balance. Milk fat, source of saturated fat, which can supress muscle mass being used for energy.

Milk and weight loss

The calcium and vitamin D content of milk has been found to be effective in losing weight. These nutrients are involved in the thermogenesis and lipid oxidation and increased lipid faecal excretion. Additionally, milk proteins are considered as reducers of adipose mass, body weight and whey protein appears to increase satiety and decrease appetite.

Milk and glowing skin

The nutrients of the milk help skin look its best. Vitamin B content of the milk supports cell metabolism and expansion of cells, giving a glowing skin. The amino acids help keep skin moisturized. Zinc of 0.5 mg/100 milk is highly bioavailable which also contributes skin health in the body. Use of goat milk on skin surface helps in glowing and reduces unevenness of skin.

Milk and eye health

Riboflavin and Vit A present in milk reduces the risk occurrence of cataracts, glaucoma and night blindness.

Milk and other health benefits

- Calcium in milk aids heart pump by providing muscles ability to contract.
- Drinking milk helps to keep away high blood pressure and stroke.
- Lactose in the milk aids liver to reduce the production of LDL cholesterol.
- Milk can assist to improve vision.
- Milk improves the mental health and restore brain activities through zinc supply.
- Milk can help to prevent Heartburn.
- Drinking milk may reduce the risk of Obesity.
- Milk products have anti-inflammatory effects if not allergic to milk.

MILK FATS AND ITS IMPACT ON HEALTH PROMOTION

Milk Fat (MF) by virtue of its composition and physicochemical properties improves the satiety value of diet. In the digestive system milk fat are digested post carbohydrate absorption which stays for longer duration as compared to proteins. Milk fast are very good repository of oil soluble vitamins A, D, E and K. The composition of the lipid fraction in milk is dominated by TG (97%-98%). The remaining percentage is composed of phospholipids (1.0%), cholesterol (less than 0.5%), 1,2-diacylglycerol (2%), FFA (0.1%), monoacylglycerol, cholesteryl ester, and hydrocarbons [13]. Components of milk fat for health promotion are presented in Table 1. Despite the saturated fat content in milk, milk and milk products has neutral or even a positive cardiovascular or overall health effect and helps to reduce contrary to previous assumption of negative effect. Milk fats reduce the risk heart disease, stroke, type 2 diabetes, blood pressure and help to raise HDL cholesterol. The fatty acid composition of milk is predominantly Saturated Fatty Acid (SFA-70%) followed by Monounsaturated Fatty Acid (MUFA - 25%) and Poly Unsaturated Fatty Acid (PUFA–2% to 3%). Milk is characterized by a relatively high content of low molecular weight fatty acids, with approximately 400 different fatty acids, where butyric acid (C4:0) is the primary constituent. Medium-chain fatty acids (C6:0-C12:0) have beneficial effects on metabolic health and improve insulin sensitivity. Under certain *in vivo* conditions, they may reduce intestinal injury and protect from hepatotoxicity. α-linolenic acid is another major PUFA in milk; it comprises 0.5%-2% of the total fatty acid composition in milk. Palmitoleic acid (cis and trans C16:1) and oleic acid (C18:1) are the MUFAs with quantitative significance in the dairy lipid fraction. They represent 1%-2% and 20%-30% of the total fatty acid composition in milk fat, respectively. Fatty acids of C18:1 is suggested as a dietary element reducing the incidence of metabolic diseases. Milk supplemented with C18:1 and in combination with folic acid and vitamins A, B6, D, and E reduce total, LDL, and HDL cholesterol in subjects with metabolic syndrome and moderate CVD risk. Milk fats put a stop to ulcerative colitis, cancer, and atherosclerosis and do not exert hyper cholesterol emic or thermogenic effects in the human body Bhavadharini et al, found that higher intake of whole fat dairy is associated with lower prevalence of MetS (Table 1) [3].

Table 1: Components of milk fat for health promotion.

Sl No	Fat components	Health impact
1	Triglycerides (97–98%)	Prevent ulcerative colitis and cancers, anti atherogenic. No impact on cardiovascular disease, responsive to hormonal activities
2	Other like Di-glycerides (2–3%)	Anti-viral, anti-bacterial
3	Cholesterol less than 0.5%	Brain development, protect nerve fibres
4	Phospholipids 1%	Aid brain health and early brain development, improve gut lining and liver function, anti-oxidant
5	Fatty acids * Saturated fatty acids 70% Unsaturated fatty acids 30% Mono unsaturated 25% Poly unsaturated 2-3%	Provides energy, responsive to hormones Regulate biochemical process in body
5.1	Free fatty acids (FFA) 0.1%	
5.2 5.2.1 5.2.2	Short Chain Fatty acids 11% Butyric acid Caproic acid	Provides quick energy for muscles, heart. Liver. Kidneys blood platelets and nervous system , weight control, improves gut health
5.3	Medium chain fatty acids	Metabolic health and improve insulin sensitivity, prevent chronic inflammatory diseases, weight control
5.4	Long chain fatty acid Myristeac acid (C14) acid Steriaric acid (C18) Oleic acid (C18:1)	Increases HDL cholesterol Prevent CVD Anti atherogenic and Promotes positive health effect

6	Conjugated Linoleic acid	Cancer fighting properties, anti-inflammatory anti-oxidant , anti-sclerotic, reduces blood pressure, anti-diabetic, anti tumour, Immunomodulatory
7	Sphingolipid	Function as bacteriostatic, anti-cancerous and cholesterol lowering ability

Note: *Gomez-Cortes et al. 2018 [14].

Conjugated Linoleic Acids (CLA)

CLA are present in milk and are produced naturally by ruminants from linoleic (18:2) and linolenic (18:3) polyunsaturated acids. It represents 0.3 to 0.5% of the total fatty acids in milk [15]. The primary CLA isomers in dairy fat is cis-9 and trans 11 CLA (70-90%); the second most frequent CLA is trans 18:1 isomer is vaccenic acid. Both the cis-9, trans-11 (rumenic acid) and trans-10, cis-12 CLA isomers have been recognized as having antitumor capabilities in the inhibition of angiogenesis in mammary tissues. Many in-vitro studies suggest that consumption of certain amount of CLA provides anti-carcinogenic, anti-diabetic, anti-atherogenic, apoptotic, immunomodulatory, and osteo- synthetic effects (Figure 2). It also helps in increasing the bone and muscle mass. Metastatic expansion of tumours is inhibited by CLA which has been found very effective in controlling cancer proliferation. Both malignant and benign tumours are effectively blocked by CLA. Impact of supplementation of CLA (1:1 mixture of 9-CLA and 10-CLA) at the rate of 3g/day on immune system, plasma lipid profile and glucose have been studied and it suggests that the plasma IgA and IgM level shoot up while IgE level and pro-inflammatory cytokines decreased significantly. CLA in diet to furnish the metabolic benefits is only achieved at a level of 3g/day and above [16]. CLA also actively blocks the replication and synthesis of DNA which helps in apoptosis or programmed death of cells, an important feature required in inhibiting proliferation of several cancerous cells. It plays important role in anti-atherosclerosis by reducing LDL-cholesterol levels and increasing anti-atherogenic HDL-cholesterol thus preventing deposition of lipids in medium and large arteries (Figure 2).

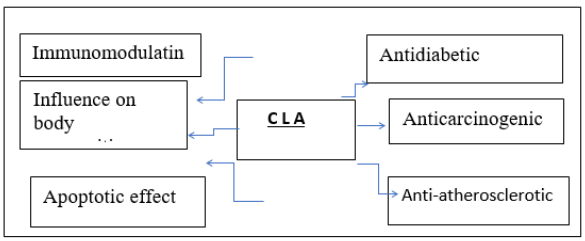

Figure 2: Bioactivity of Conjugated Linoleic Acid (CLA).

HEALTH PROMOTING FEATURES OF MILK PROTEINS

Milk proteins (80% casein and 20% whey) possess very high biological value and of huge importance for maintaining the health of muscle and its growth. The protein efficiency ratio of casein is in the range of 2.89-3.10. Milk proteins are good source of all the essential and non-essential amino acids (Table 2). Proteins play vital role in muscle functions, body's immunological health and their maintenance. They also furnish energy 4 Cal/g (Table 2). Apart from basic nutrition, milk proteins offer several functional benefits which helps in supporting good metabolic and overall health. These proteins have shown positive impact on complications like hypertension, dyslipidaemia, and hyperglycaemia etc. Whey fraction exhibits retinol binding properties and contains immunoglobulins and mineral binding features. The Branched Chain Amino Acids (BCAAs) from whey have been found to show insulinotropic effects. Whey proteins also supplements in lipid metabolism and decreases postprandial triglyceride response in body. Consumption of whey proteins prior to carbohydrate rich diet has shown reduced post prandial glucose response and favours insulin independent reduced blood glucose levels. Consumption of whey protein and casein 54 g/day for 84 days have shown to reduce diastolic blood pressure in non-hypertensive subjects. A peptide (NOP-47) obtained from whey helped in betterment of arterial vasodilation in subjects when given for a period of 14 days 5 g/day [17]. Administration of whey protein hydrolysates 28g/day for a period of 42 days, reduced blood pressure as compared to the baseline pressure before treatment.

Table 2: Major health benefits of milk proteins

Type of protein	Biological function	Outcome
Casein		
Whole casein	Anticarcinogenic activity	Protect against colon cancer Decreasing the incidence of chemically induced intestinal tumors
	Hypocholesterolemic effects	Reduction in the total cholesterol, LDL-C, HDL-C and lipoprotein (a) concentrations
k-Casein	Anti-cariogenic activity	Reduction in the activity of the plaque-promoting enzyme Inhibiting the adherence of Streptococcus mutans to the S-HA surfaces of teeth
β-Casein	Hypocholesterolemic effects	Reduction in blood cholesterol levels
Whey proteins		
Whey protein concentrate	Anticarcinogenic activity	Inhibition of incidence and growth of chemically induced tumours
	Immunomodulation	Higher mucosal antibody responses to antigens Impact on T-cell populations, increase in the T-helper cells concentration and T-helper cells/T-suppressor cells ratio
β-Lactoglobulin	Anticarcinogenic activity	Stimulation of the glutathione synthesis
	Antiviral activity	Inhibition of HIV-1 protease and integrase activities
α-Lactalbumin	Anticarcinogenic activity	Antiproliferative action on colon adenocarcinoma cell lines
	Antibacterial and antiviral activity	Reduction in cell numbers of the infant faecal E. coli

Lactoferrin	Anticarcinogenic activity	Antiproliferative, anti-inflammatory and antioxidant activities
	Immunomodulating	improving delayed-type hypersensitivity responses to a range of antigens
	Antibacterial activity and antiviral activity	Inhibitory effect against H. pylori Inhibition of HIV-1 reverse transcriptase, protease and integrase activities
Immunoglobulin	Antibacterial activity	Prevention of shigellosis Protection against oral challenge with enterotoxigenic E.coli
	Anticariogenic activity	Slight inhibitory activity against S. mutans adherence to S-HA (saliva-pre-treated hydroxyapatite)
Bioactive peptides		
Lactoferricin	Anticarcinogenic Activity	Cytotoxic, antitumor, and apoptotic activity against cancer cell lines
	Immunomodulation	Increase in Igs (IgM, IgG, and IgA) production
	Antibacterial activity	Growth inhibition of diverse range of Gram-positive and Gram-negative bacteria
	Antihypertensive activity	Inhibition of ACE activity and ACE-dependent vasoconstriction
Serokinin	Antihypertensive activity	Inhibition of ACE activity and ACE-dependent vasoconstriction
Lactorphin	Antihypertensive activity	Decrease in blood pressure in hypertensive rats
Casokinin	Antihypertensive activity	Decrease in blood pressure in hypertensive rats
Lactokinin		
Casopletelin	Anti-thrombotic	Prevent thrombosis, blood clotting
Casein-phosphopeptides	Anticariogenic activity, Mineral binding ability	Stabilization of calcium phosphate and decreasing the mineral loss
Kappacin	Antibacterial activity	Inhibition of S. mutants, Porphyromonas gingivalis and E. coli
Glycomacropeptide	Antiviral activity	Inhibition against human influenza virus and Epstein Barr virus
	Immunomodulation	Indirect anti-inflammatory effect of intestinal by Promotion host defence against microorganisms
α/ β-Casomorphin peptides	Anticarcinogenic activity Opioid activity	Decrease in proliferation of prostatic cancer cell lines Promotion of apoptosis in human leukemia cells (HL60) Induces sleep

Hydrolysis of milk proteins (Functional Bioactive peptides)

Milk protein when subjected to controlled enzymatic or fermentation or gastrointestinal transit, it yields several smaller fractions or group of amino acids known as peptides exhibiting health promoting features that can modulate physiological functions of body [18].

Bioactive peptides from milk and their impact on human health is reviewed by Figure 3 [19]. Bioactive peptides from milk proteins are released by degradation of both casein (αs1, αs2, β, and κ-casein) and whey proteins (α-lactalbumin, β-lactoglobulin and lactoferrin). Majority of these are produced by β caseins (36%) followed by αs1-casein (13%), βlactoglobulin (11%), κ-casein (10%), αs2-casein (8%) and α-lactalbumin (5%) and serum albumin (< 1%) [20]. These peptides show a range of activities including Angiotensin Converting Enzyme (ACE) inhibition, Dipeptidyl Peptidase IV (DPP-IV) inhibition, opioid agonist and antagonist, antimicrobial, antithrombotic, immunomodulation, mineral binding and antioxidative functions. Bioactive peptides released from milk proteins by various microorganisms is presented in Table 3. Opioid and immunomodulatory peptides were the first identified bioactive peptides from milk [21]. It has been reported that the activities are highly dependent on the amino acid composition, as well as the specific amino acid sequence of the peptides (Figure 3).

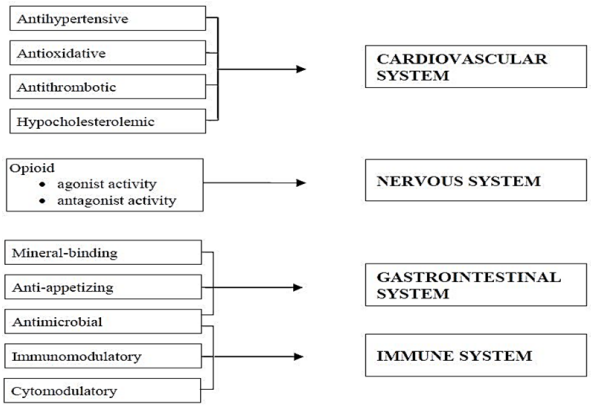

Figure 3: Different bio-active peptides and their functions.

The casein derived β-casomorphines are opioid peptides which exhibits morphine like effects whereas the k-casein derived casoxins and lactoferrin derived lactoferroxins act as opioid antagonists. Whey proteins furnish opioid peptides like α-lactorphins and β-lactorphins from its α-lactalbumin and β-lactoglobulins fractions. These were found to moderately impart the ACE-inhibition properties. Lactoferricin derived from lactoferrin exhibits antimicrobial, antifungal, antitumor, and antiviral properties. Casein derived casokinins and whey protein derived lactokinins act as potent ACE inhibitory bioactive peptides that blocks the conversion of Angiotensin I to Angiotensin II which is considered as vasoconstrictive in nature (Figure 4).

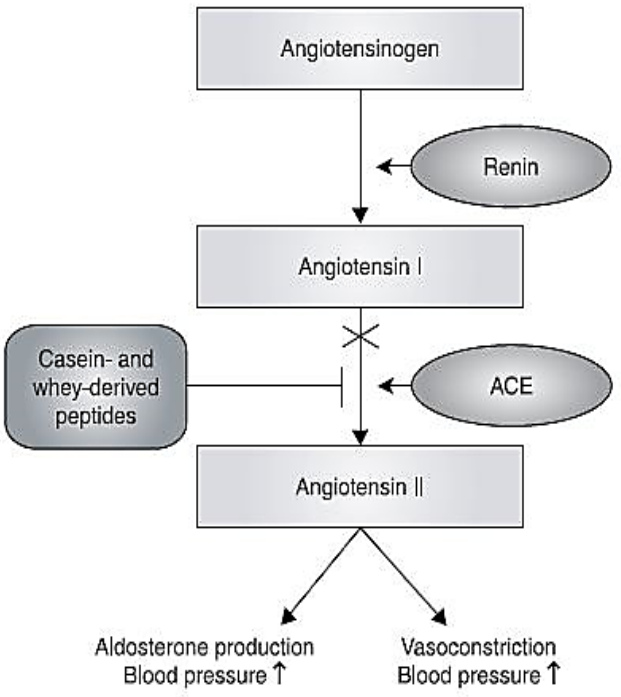

Figure 4: Conversion of angiotensin I to angiotensin II does not occur as the bioactive peptides from milk protein stops the functioning of angiotensin-converting enzyme (ACE). The angiotensin II has vasoconstrictive effect which leads to higher blood pressure [61].

Functional components from milk proteins

Health promoting benefits derived from milk protein fractions and its hydrolysates are summarised in Table 2.

Antihypertensive peptides: Hypertension is a key challenge to the health of public that results in complications of cardiovascular system which comprise coronary heart failure, congestive heart failure and heart attack. Angiotensin converting enzyme that has a key role in maintenance of blood pressure and which bring about the degradation of dipeptides. It converts angiotensin I to angiotensin II, which results in high blood pressure. It also causes degradation of the vasodilator's bradykinin and kallidin, which leads to constriction of blood vessels and aldosterone release, elevating concentration of sodium and blood pressure. The mechanism is outlined in the Figure 4. Aluko has explained the various biomarkers or signs that shows an antihypertensive action of milk-derived bioactive peptide, i.e., renin-angiotensin inhibition. ACE inhibition [22,23]. Approximately 420 milk-derived ACE inhibitory peptides with IC50<1000 mM have been isolated from milk proteins. The caseins contributed 77% of the ACE inhibitory peptides [20].

Antidiabetic peptides: Diabetes Mellitus (DM), a chronic disease caused due to insufficient insulin secretion by Pancreas or its action. Type 2 Diabetes (T2D) is most prevalence which accounts for about 90% of all diabetes. Various strategies are being used to manage or control T2D. One therapeutic approach is the use of carbohydrate hydrolysis inhibiting enzymes in digestive organs and another therapeutic approach is the use of glucose-lowering agent, i.e., Dipeptidyl Peptidase-IV (DPP-IV) inhibitor (Figure 5).

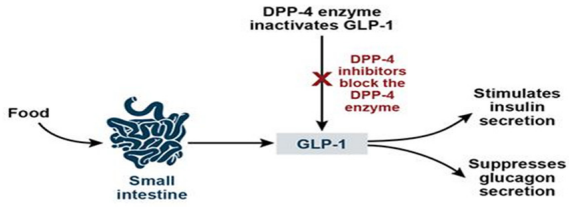

Figure 5: Mechanism of action of DPP-IV inhibitors derived either from casein or whey protein.

The incretin hormones, GLP-1 and GIP are gut hormones released into plasma after ingestion food. A DPP-IV enzymes inhibitor enhances the exogenous and endogenous GLP-1 and GIP action by blocking their N terminal degradation and hence inactivation occurs. Caseins appeared to be best potential sources of DPP-IV inhibitorsand β-casein showed a greatest potential amongst milk proteins to serve as source of DPP-IV inhibitors [24]. Silveria, et al. also reported anti diabetic (on type type 2) properties of β-lactoglobulin peptides (Figure 5) [25].

Antioxidative peptides: Antioxidants are the substances which may safeguard your cells against free radicals. Free radicals have adverse effects health, cancers, and other diseases. Consumption of antioxidant rich diet can benefit the defence mechanism to fight against formation of free radicals and oxidative stress. The antioxidant activity of bioactive peptides depends on their ability to lessen free radicals paired with the movement of metal chelating property [26]. Antioxidative action of peptides is regulated by the molecular weights, Amino Acid (AA) sequence, and their properties including hydrophobicity, acid/base character, and hydrogen donating property [27]. Antioxidant peptides from milk have 5–11 AA with higher hydrophobic AA such as His, Pro, Trp, and Tyr [28]. β-casomorphin-7 derived from β-casein exhibits an antioxidative property by increasing the activity of enzymes such as superoxide dismutase, glutathione peroxidase, and catalase [29]. Fermented Dairy products produces antioxidant peptides which can either control the free radical formation or scavenge the free radicals or peroxides. Histidine chelates and traps free radicals, while Tyrosine may act as the hydrogen donor to reduce free radical [30]. Most of the antioxidant peptides of milk are from casein, i.e., from αs1casein, and β-casein.

Anti Hypercholesterolemic Peptides: Cholesterol plays an important physiological role in human body. It can be one of the major factors for heart disease. It is normally produced in the liver. It exists in the blood as free cholesterol or bound with protein in different forms but the most important forms being the Low- and High-Density Lipoproteins (LDL and HDL). High cholesterol levels in the blood (especially LDL) is one of the factors, among many others, which cause heart disease through atherosclerosis [31]. It can be controlled through diet including some of the constituents in foods are like plant protein, soluble fibres, plant sterols, probiotics and prebiotics [32]. Some milk protein hydrolysates with small peptides having molecular wt<10k, mostly the di- and tripeptides, could also inhibit 3-Hydroxy-3-Methylglutaryl Coenzyme A (HMG-CoA) reductase to exhibit a similar effect to that of statins (LDL cholesterol reducing drug). Human studies demonstrated the hypocholesterolemic effect of fermented milk products [33].

Tryptic hydrolysate of β-lactoglobulin shows a preventive

mechanism of cholesterol absorption through direct interaction with the cholesterol [34].

Antimicrobial peptides: Lactoferricin derived from lactoferrin exhibits antimicrobial, antifungal, antitumor, and antiviral properties.

HEALTH PROMOTING FEATURES OF LACTOSE

Lactose content of 4.6%–4.8% in bovine milk is lower than in human milk of about 7%. Lactose, is a disaccharide occurs exclusively in the milk of mammals which is composed of galactose and glucose. More than 50% energy requirement of the infants is supplied by the lactose and its derivatives [35]. Glucose and galactose play an important biological role in the body and provide major source of energy. Lactose is utilised for brain development through the galactocerebroside [36]. Besides lactose, oligosaccharides are present of about 15%-18% of the total sugars in milk as lactose derivatives. These oligosaccharides act as prebiotics in the intestine and exhibit many physiological functions along with useful microbial growth in the gut including growth of Bifidobacterium bifidum which is naturally present in the gut of breast-fed babies enhancing their general health [37]. Galactose in human body have very vital importance and it is also considered as one of the 8 essential sugars required for mammalian body to function properly. Galactose have also been reported to enhance health benefits through the reformation of the protective mechanism against pathogens. Galactose also helps in growth of brain cells by synthesising galactosidases, medullar sheaths of nerve tissues and cerebrosides in infants, hence also known as "Brain Sugar". Galactose constitutes a major part of cellular systems, cell walls and intercellular matrix.

Lactose is less sweet than sucrose. It is about 60% to 70% less sweet than sucrose. Insulin response is significantly lower after the ingestion of milk. Low glycaemic index of lactose (about half of sucrose) is attributed to two factors. Firstly, slow digestion of lactose in the small intestine is due to presence protein. Secondly, Galactose component gets converted into glucose in the liver before it can contribute to the blood glucose level and due to presence good amount of calcium in milk. Slow digestion and metabolism of lactose favours better glycaemic response and it also tends to be less problematic to stomach and intestinal mucosa as compared to sugars with high glycaemic index. Lactose has a Glycaemic Index (GI) of 45 and galactose has GI of about 25 whereas glucose has the GI of 100. Hence it is evident that lactose and galactose has very less impact on blood sugar levels. In large intestine lactose favours the growth of lactobacilli which is found to synthesise many vitamins (predominantly vitamin B) and enzymes as a fermentation product. Absorption of several mineral compounds like calcium, magnesium, phosphorous etc. are found to increase when lactose containing diet is supplemented with it. The monomers constituting lactose (galactose and glucose) gets converted into glycogen in body. Overall lactose favours several health promoting features in diet as compared to many other forms of sugars in common use.

Functional components

Lactose can be degraded by enzyme lactase and or through fermentation. Due to microbial fermentation lactose is broken down to galactose, glucose, lactic and other organic acids like acetic acid etc. All these derivatives show their impacts on different health promoting activities. Lactose is hydrolysed by lactase enzyme which resolves the problem of lactose indigestion for lactose intolerant patients. Galacto Oligo Saccharides (GOS) are also produced due to hydrolysis of lactose by galactosyl transferase which help to suppress the activity of enzymes and transform pro carcinogens to carcinogens leading to proliferation of Bifidobacterium. This stimulates cell wall and extracellular immune system components [38]. GOS has shown anti-cancerous effect in colon. Fermentation of GOS (degradation of GOS by intestinal microflora in large intestine) results in the production of butyrate, which serves as a fuel for colonic epithelial cells and stimulates apoptosis. Fermentation of GOS also produce propionate, an anti-inflammatory substance to colon cancer cells. Feeding of GOS in combination with mixture of probiotic bacteria significantly reduce IgE-associated diseases, eczema, and atopic eczema. GOS have shown to improve iron bioavailability, anti-carcinogenic activity and protect against DNA damage. Physiological functions of lactose are: act as prebiotic, react as immunomodulatory agent, improves mineral absorption, show anti -carcinogenic effect and exhibit anti-arteriosclerosis effect. Health perspective of lactose are: i) gets fermented in the colon ii) enhances absorption of calcium and magnesium iii) controls chronic constipation and iv) helps in higher calcium absorption (10.3%) compared with a lactose-free formula.

The hydrolysed products of lactose like lacto sucrose, lactitol, and galactose - oligosaccharides have potential prebiotic properties in addition to enhance mineral absorption, reduction serum lipids, lessen the risk in intestinal infections and colon cancer. Lactulose is formed on heating of lactose, in which the glucose moiety is epimerized to fructose. It is accepted as a bifidogenic factor and present in heated milk (up to 0.2%). Lactulose is non digestible, and acts as a soluble fiber which alleviate constipation and chronic encephalopathy, stimulate the immune response, enhance calcium absorption in infants. It also stimulate the growth of Bifidobacterium bifidum in the lower colon area of the human gastrointestinal tract. Similarly, lactosucrose is recognized as a bifidogenic factor due to its ability to enhance the amount of faecal bifidobacteria and effectively modify the faecal flora in patients with inflammatory bowel disease. Lactitol is sugar alcohol produced from the catalytic hydrogenation of lactose. It has been shown to significantly reduce the activity of pro carcinogenic enzymes and aromatic compounds in the colon, when 20 g/day is administered [39]. It has less calories than sucrose.

MICRO COMPONENTS

Milk contains minor components such as vitamins, minerals, enzymes, pigments (carotene, xanthophyll, and riboflavin), phospholipids and sterols.

Vitamins: Vitamins are required for growth and maintenance of health. Milk furnishes all essential vitamins required for proper nutrition and health. Water-soluble vitamins like thiamine (vitamin B1), riboflavin (vitamin B2), niacin (vitamin B3), pantothenic acid (vitamin B5), vitamin B6 (pyridoxine), vitamin B12 (cobalamin) and folate are normally present in milk. Choline (16 mg/100 g 2.0% fat milk) in milk behaves nutrient like the B vitamins. It is important for sleep, muscle movement, learning and memory. It also helps nerve signals, fat absorption and inflammation. Fat soluble vitamins A, D, E, and K are present in k and milk products depending on the fat content of the products. Vitamin A or retinol is vital for good eyesight and healthy skin. It also keeps mucous membranes healthy and protects from infection. Milk and colostrum have high level of vitamin A activity as retinol. Vitamin D is important for absorption of calcium and phosphorus.

It is present about 50 IU/100 ml and it is present mainly as vitamin D2 and vitamin D3 forms. Vitamin D can also act as a hormone. Milk also contains minor quantity of vitamin E, an antioxidant which prevents the oxidation of carotenoids, vitamin A and polyunsaturated fatty acids. It also protects from muscular dystrophy. The vitamin K (small amount) in milk is required for synthesis of pro-thrombin which is vital for normal blood clotting. Milk is also a good source of vitamin B complex. A litre of milk can supply all the daily recommended requirement of riboflavin, which is helpful in oxygen uptake and supports adapting the eye to light. Thiamine found in milk is required for proper appetite and healthy digestion. Enough vitamin B12 and folic acid is present in milk. These are necessary for synthesis of RBCs and nucleic acids.

Minerals: Milk contains all the essential minerals required by human body in varying proportion except iron and magnesium, copper and sodium in which milk is considered deficient. Milk minerals play major role in the human physiological functions. It is known that bioavailability of minerals is usually higher from animal sources, including milk, compared to that from plants. Milk is a good source of calcium, magnesium, phosphorus, potassium, selenium, and zinc. Many minerals in milk are associated together in the form of salts, such as calcium phosphate etc. In milk approximately 67% of the calcium, 35% of the magnesium, and 44% of the phosphate are salts bound within the casein micelle and the remainder are soluble in the serum phase. The calcium and phosphorous content in milk are one of the best sources of these minerals in bioavailable form. The assimilation of these minerals is compounded by the presence of lactose in milk which favours enhanced absorption of calcium and phosphorous. Also, the widespread acceptance of milk and dairy products make it best suited for Vitamin-D fortification which further enhances the absorption of calcium. Even when iron content is not ample in milk system but whatever quantities of iron is there it is found in best suitable form for absorption by body. The dietary calcium helps in reducing the total serum cholesterol and LDL cholesterol specifically, but it positively increases HDL cholesterol concentration. The supplementation of 2.0 g calcium alone or in combination with 800 ID Vitamin D3 for 6 months may reduce serum triglyceride and possibly total cholesterol [40]. Dietary calcium also helps in controlling several metabolic syndromes apart from providing healthy bone and teeth. Dietary calcium is thought to reduce the absorption of fat in the intestine by specifically interacting with the Saturated Fatty Acids (SFA). This results in formation of soap like compounds which remains insoluble in the intestine. Because of this phenomenon the faecal excretion of fat increases which finally results in improved lipoprotein profile in blood serum. As SFA causes increase in the LDL cholesterol by inhibiting the LDL receptors, hence binding of SFA by Calcium results in definite reduction in serum LDL cholesterol. Another mechanism which explains the relation of dietary calcium and reduction in LDL cholesterol is that calcium binds with bile acids which are then excreted out. This results in reduction of Bile acids (BA) and to maintain the balance of BA there happens conversion of more of LDL cholesterol in the liver to BA which results in decreased amount of LDL cholesterol.

EFFECT OF DAIRY CALCIUM AND OTHER MINERALS ON BLOOD PRESSURE

Calcium is a vital mineral essentially require in the human body. It is a key nutrient required in numerous biological functions in the body such as skeletal mineralization. Intake of calcium also affects the blood pressure favourably. Its metabolism in health and disease is described by Peacock 2010 [41]. There is an inverse relation between calcium contents and blood pressure in milk. Membrane permeation of monovalent and divalent cations is reduced along with increased excretion of sodium ions which results in reduced blood pressure [42]. Higher intake of dietary calcium causes reduction in the hormone. The effect of 1,25- dihydroxy vitamin D is to regulate adipogenesis in human [43]. Binding of calcium with 1,25- dihydroxy vitamin D causes reduction in intracellular calcium inflow which results lipolysis like situation and decrease the reserves of triglycerides. The process can be explained as mentioned in Figure 6.

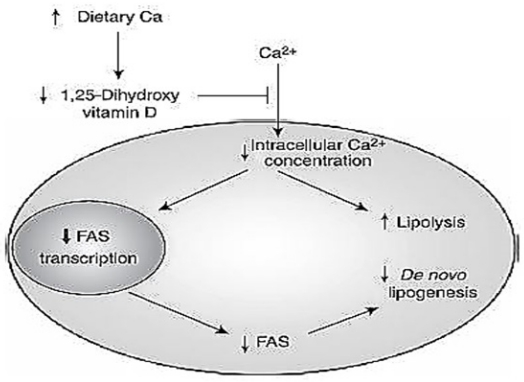

Figure 6: The mechanism of inhibition of intracellular calcium influx by interaction with 1, 25- dihydroxy vitamin D hormone which leads to reduction in synthesis of fatty acids and decrease in triglyceride reserves of cell [61].

Calcium present in milk and milk products are in the form of calcium phosphates complex which helps for better absorption in the intestine in comparison to calcium carbonates, acquired from other dietary sources. It is also reported that calcium intake has an influence on weight control and fat accumulation in body.

Potassium and magnesium in dairy products help in reducing blood pressure. About 1.2 g/L calcium and a fairly good amount of potassium and magnesium are present in milk. Magnesium (about 10% of calcium) plays an active role in the transport of calcium and potassium ions across cell membranes. This is an important phenomenon for the nerve impulse conduction, muscle contraction, and normal heart rhythm. Potassium (about 160 mg/100 g milk) helps blood vessels to dilate and reduce blood pressure. It also reduces the risk of occurrences of stroke and heart diseases. Lactose, citrates and protein derived peptides help in enhancing the bioavailability of calcium and other minerals like magnesium, zinc and selenium and it promote the metabolic health benefits. The deficiency of dietary calcium has been linked to osteoporosis for decades, a metabolic bone disease usually related with a decrease in bone density and increased porosity, fragility, and risk of fracture. Of course, osteoporosis has been co related with genetic, environmental and lifestyle besides role of nutrients. It can be assumed that there is a positive relation between calcium and bone health especially above 40 years person. However, more investigations are required to establish the influence of vitamin K in maintaining bone density [44]. The importance of vitamins and their physiological role in improving health through the prevention of many diseases has been known since long time.

MILK PRODUCTS

Varieties of milk products are available in the world. Converting milk into milk products allow the preservation of milk for days, weeks or months and help to reduce food-borne illness. The conversion of raw milk into processed milk and milk products can benefit consumers and processors to generate higher revenue by reducing transportation cost and availing wide marketing scope. Consumers can get option to select products depending on their choice/preference/taste, illustrates the process flow of milk products (Figure 7).

Fermented milk products

Fermented milk products have exhibited a positive effect on the human digestive system and plat a vital role to control of serum cholesterol. Lactose and protein in fermented milk are more easily digestible than those in the original milk. Proteins are partly degraded by the action of the bacterial proteolytic activity (Table 3) whereas lactose content gets reduced in fermented milk products than that of milk. Lactose is converted to lactic acid (Table 3). Lactic acid provides characteristic sour taste associated with fermented products. Yoghurt and fermented milks may contain more folate than the original milk as some strains of lactic acid bacteria synthesize folate [45]. Fermentation not only makes milk more digestible but also increase the shelf-life and microbiological safety of the products. Several bioactive components are produced due to microbial action in fermented of milk products as reported by several researchers effecting in health promotion (Table 4).

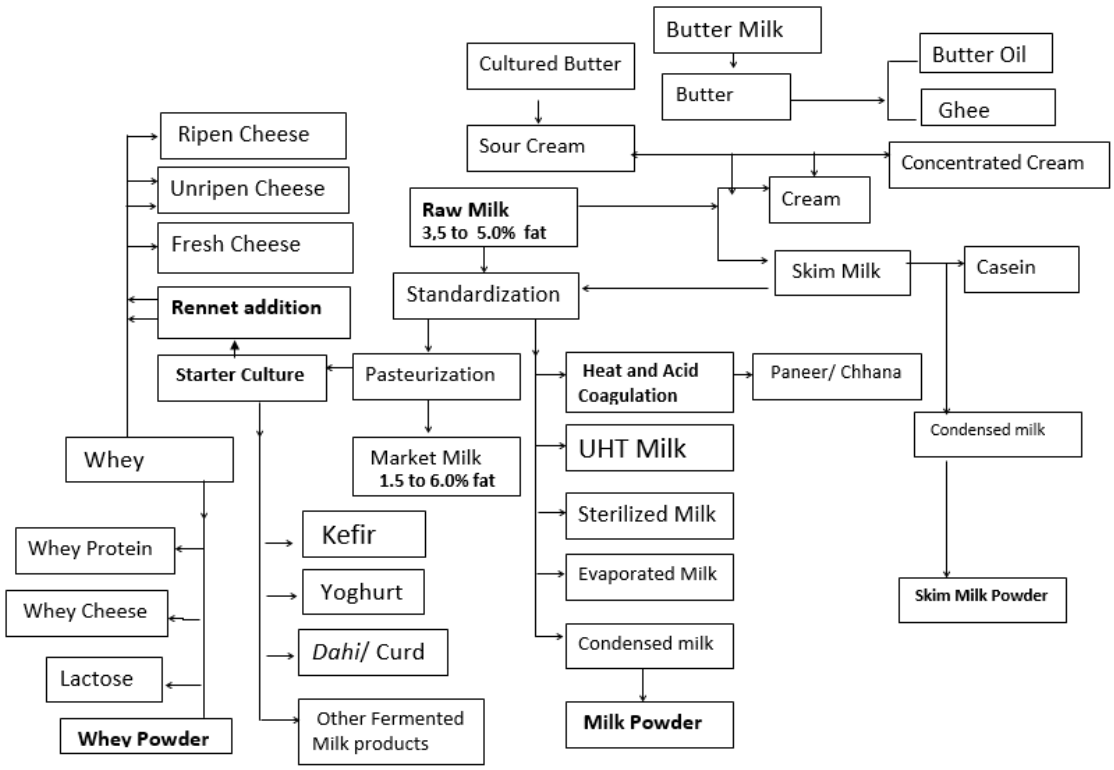

Figure 7: Milk Products and their processing.

Table 3: Bioactive peptides released from milk proteins by various microorganisms

Microorganism	Precursor protein	Bioactivity
L. rhamnosus + digestion with pepsin	β-cn	ACE inhibitory
Lactobacillus helveticus	β-cn, κ-cn	ACE inhibitory, antihypertensive
Saccharomyces cerevisiae	β-cn, κ-cn	ACE inhibitory, anti-oxidative
Lactobacillus GG enzymes + pepsin and trypsin	β-cn, as1-cn	Opioid, ACE-inhibitory, immune-stimulatory
Lactobacillus delbrueckii subsp., bulgaricus IFO13953	κ-cn	ACE-inhibitory, Antioxidative
Lactobacillus helveticus CP90 proteinase	β-cn	ACE-inhibitory

Table 4: Bioactive components in fermented dairy products and the bioactivity as reported.

Dairy products	Bioactivity and suggested health effect	Study design	Study design
Sour milk	Reduce hypertension	Placebo controlled study	Hata Y et al.1996 [46]
Dahi	ACE inhibitory	*In vitro*	Ashar MN et.al [47]
Yoghurt	ACE inhibitory	*In vitro*	Donkar et al. 2007 [48]
Ripened Cheese	ACE- inhibitory	*In vitro*	Meisel et al. 1997 [49]
Cheddar cheese	Antioxidant, antimicrobial, and ACEinhibitory	*In vitro* study	Pritchard et al. 2010 [50]
Gouda cheese	DPP- 4 inhibitory peptide Beneficial effect on abdominal adipose	Animal study Animal study (Rat)	Uenishi et al. 2012 [51] Higurashi et al. 2007 [52]
" Festivo" cheese	ACE - inhibitory	*In vitro*	Ryhanen et al. 2001 [53]
Italian cheese (Mozzarella, Italico, Crescenza and Gorgonzola)	ACE-inhibitory	*In vitro*	Smacchi et al 1998 [54]
Cottage	Antioxidant		Abadia Garcia et al. 2013 [55]
Enzyme modified cheese	Opioid activity, ACE inhibitory		Haileselassie et al. 1999 [56]

Yoghurt: It is manufactured using adventitious lactic acid bacteria where pH of milk gets reduced through fermentation of lactose to lactic acid. Two specific organisms in different combinations are used to reduce the pH of milk. Plain yoghurt and cultured milk are protective against T2D [9].

Dahi: A traditional Indian fermented milk product like Yoghurt, intended for direct consumption. It is being produced using mix mesophilic lactic starter organisms. India is the largest milk producing country now in the world and dahi is an age-old Indian household fermented milk product. It has managed to retain its popularity and remain part of the Indian diet regardless changing food habits and lifestyles. Dahi is further converted into Shrikhand after draining out the whey and mixing the curd mass with sugar and flavouring agent. Sweetened dahi (Misti Doi) and lassi (stirred curd admixed with desired sugar) are the traditional fermented milk products. Dahi is reported to be very nutritious, predominantly natural diacetyl flavoured and possess several therapeutic properties.

Cheese: Cheese is one of the main fermented dairy product in which the hydrolysis of milk proteins leads to generation of numerous peptides. Numerous biologically active substances are produced (Figure 8). Cheese is normally classified based on the type of milk used, manufacturing process, fat content, type of fermentation, and type of microorganisms used [57].

Cheeses are available with wide range of flavours, textures from milk protein casein. It may be in the form of blocks, slices, cut, shredded, or grated cheese. Among ripened or un ripened, soft, semi-hard, hard, or extra-hard cheese varieties, ripened cheeses show better health benefits, easily digestible due to hydrolysis of proteins by action of rennet and starter microorganisms of the cheeses. Some of these benefits are mentioned in the Table 3. Bioactive compounds produced during cheese ripening have health benefits which are related to milk protein mainly on casein and its hydrolysed products [58]. Fats are also partially broken to fatty acids which help in digestion and absorptions (Figure 8).

Since, cheese is made with rennet and lactic acid bacteria where almost all whey proteins and lactose are drained out in the whey. Fat, casein and residual amount of whey protein and lactose play major roles in production of health promoting sapid compounds for the consumers. Almost all fat soluble vitamins, partly water soluble vitamins and minerals are retained in concentrated forms in cheese.

Other fermented products: Hundreds of fermented milk products are available in the world depending upon the geographical location, socio cultural tradition and localised preferences. Since these are being manufactured from the milk or milk by products, the nutritional/health promoting significance remain same as milk. Additionally, benefits derived from microorganisms like folate, enzymes, vitamins, peptides, and different types of acids will be appended on these products.

Fat rich milk products

Fat rich products start from 20.0% to 99.6% milk fat. Milk fat related health benefits fall on the milk products depending on its fat contents. Health promoting effects from milk fat are mentioned in Table 1.

Cream: It is a viscous milk product comparatively rich in fat and in the form of an emulsion of oil -in- water in milk. It is obtained by skimming or centrifuging of milk. Fat content in cream varies from 20% to 78% depending on type of cream.

Butter: It is a water -in-oil emulsion of milk fat and is obtained by churning cream. Fat content is about 80%.

Ghee: It is generally produced from butter and the water is removed by heating of butter. At the end pleasant aroma and flavour comes out from Ghee. Whereas theses are absent in butter oil. The milk fat/mainly butter is heated at 106 °C to 120°C to manufacture ghee and its moisture content is very low in the final product which put a stop to the growth of most microorganisms in ghee. Therefore, ghee has a shelf-life of 6–8 months, or even up to 2 years. It is widely used as a cooking and frying medium in India. Often consumed directly with other food items or garnishing purpose. Ghee contains large amounts of fat-soluble vitamins: 100 g of ghee is reported to have a vitamin A content of 600 µg, 8 µg of vitamin D, 2.8 mg of vitamin E 10 µg of Vit K. The cholesterol content is reported to range from 200–400 mg/100 g in ghee. Ghee contents higher CLA than butter and or fluid milk due to higher fat in ghee (Figure 4, 6) [59].

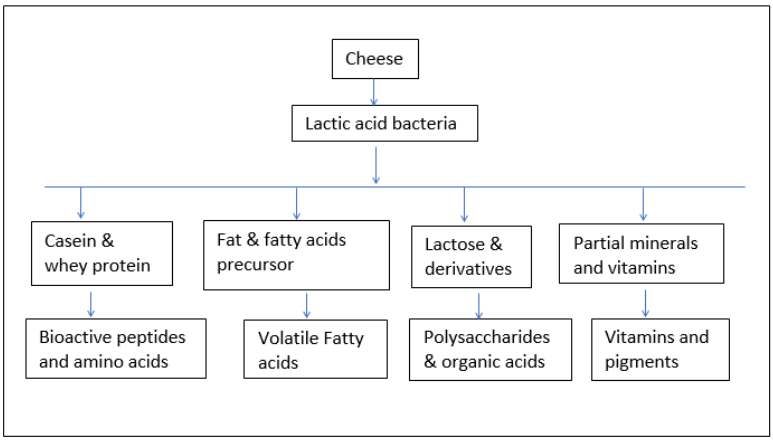

Figure 8: Role of lactic acid bacteria during fermentation or ripening of cheese.

Whey: A greenish liquid, obtain after coagulating the milk protein or after the separation of curd in cheese making from milk. In India, whey is produced after preparation of heat and acid coagulated products like Chhana and Paneer. It contains mainly lactose, less than 1% whey proteins, water-soluble vitamins, and partial minerals. There are two types of whey exist: i) acid whey, obtained during the production of acid-coagulated cheeses such as Cottage and Mozzarella cheeses, Chhana, Paneer and ii) sweet whey from the manufacture of rennet coagulated cheeses. Acid whey contains twice as much calcium as sweet whey. Health benefits are mainly as per lactose contents and other milk constituents as mentioned above. The products are:

Whey pastes or dry: It is used as food and animal feed. Lactose is major part (40%-60% followed by milk protein (8-12%), milk fat (1.5%-2.0%), water (5%-20%) and ash (8.0%-9.5%).

Whey cheeses: These are produced by condensing the whey followed by moulding of the concentrated or semi solid in desired shape or whey is further coagulated using either heat or heat and acids. Whey may be concentrated prior to further concentration or coagulation of the whey proteins. Milk, cream, or other raw materials of milk origin are added in whey before or after concentration or coagulation.

Whey powders: It contains lactose 61.0 percent (m/m), milk protein minimum 10.0 percent (m/m), milk fat 2.0 percent (m/m), water maximum 5.0 percent (m/m) and ash maximum 9.5 percent (m/m).

Lactose: The milk sugar is manufactured commercially from whey.

Other whey products: Whey Protein Concentrate (WPC) and Whey Protein Isolate (WPI) are also produced from whey.

Casein: It is the main protein constituent of milk. Casein is manufactured from skimmed milk by curdling with acids or rennet. Caseins are low in sulphur containing amino acids, which limits their biological value [60].

Concentrated and dried products

All the milk constituents present in milk get concentrated depending upon type of products, fold of concentrations and extent of heat treatments etc. Since all the milk constituents are concentrated, food value gets increased. Minor hydrolysis takes place and partial vitamins, and enzymes are lost due to the heat treatments. These products are classified as follows:

Concentrated milk: It is simply milk from where part of moisture is removed. It contains same nutrients with higher proportion than milk, but vitamins may be partially lost depending on processing conditions. Concentrated milk products, whole, reduced fat and fat free varieties of evaporated milk have a higher nutrient content than fresh milk. Sweetened condensed milks are different types like concentrated milk with added sucrose which resulted in higher calories than concentrated milk. Sweetened condensed milk contains high total solids including 45 percent sucrose with a high energy value (1343 kJ or 321 kcal/100 g). Generally, they have over twice as many grams of carbs, protein and fat except for reduced fat and fat free varieties and higher minerals contents. The followings may be the **benefits** from it:

- **Improves** brain function
- Strengthens bone tissue
- **Positive effects** on cellular metabolism
- **Boosts** immunity
- **Normalizes** hormones and **replenishes** the minerals in human body

Milk powder/Dried milks: Milk with or with fat from which water has been removed by various methods of drying. The final products appear to be in the form of powder or granules. Powder milk is an ideal replacement of fresh milk.

Milk powder contains all the milk constituents in higher concentration. Its nutritive and calorific value are higher than regular milk depending on fat contents likewise whole milk, reduced fat or skimmed milk (fat free milk) powder. All the fat-soluble vitamins either gets concentrated or reduced depending on the fat contents in the milk powder. Milk proteins content are in higher concentration. It contains higher amounts of amino acids than milk such as isoleucine, leucine, lysine, methionine, histidine, phenylamine, valine, threonine and tryptophan which are essential for good health and promote overall body function. In addition to lactose, milk powder contains glucose, oligosaccharide, and galactose. Higher lactose content in milk powder provide a scope to prepare a diabetic diets because it does not increase blood glucose level as it digested more slowly than sugar like glucose and fructose. Lactose also helps your body to absorbs calcium. All the minerals concentration will be higher than milk. However, some vitamins and enzymes may be reduced depending upon the heat treatment during its production. The followings are the **health benefits** of milk powder:

- **Aids** to repair cells and regulates immune system
- **Assists** in muscle building
- **Decreases** the risks of bone fractures and other related problems
- **Supports** to maintain a healthy heart
- **Offers** adequate amount of proteins and amino acids
- **Aids** in recovery from sickness, **Provides** instant energy
- **Improves** skin health, **Helps** in stimulating sleep
- **Keeps** the body hydrated and **Improves** digestion

CONCLUSION

Milk is an ideal food. Several milk components and the probiotics grown in it may act directly as preventive agents against diseases. Yoghurt, Dahi, and different varieties of cheeses contribute for the wellness of health. Turmeric powder in milk can provide some relieve to cough and viral infection related issues and it also improves immunity. Consumption of milk is ideal for those who are suffering from calcium deficiency for better absorption rather than taking calcium tablets. Despite of saturated fat content, it provides antihypertensive properties with other components such as vitamin D, calcium, potassium, phosphorus, conjugated linoleic acid and in addition to some bioactive peptides. Drink a glass of milk at any age, keeps you to stay fit and strong. Intake of dairy products are also associated with lower prevalence of metabolic diseases. More studies are required to explore the use milk components for preventive and therapeutic purpose.

DISCLOSURES

Conflict of interest

Both the authors declare no conflict of interest.

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