



FUNCTIONAL FOODS ROUNDUP

Healthy ingredients in milk may provide new options to develop diet-based solutions for better health outcomes.

Words by Ranjan Sharma

With lifestyle-related health concerns and diseases like obesity, cancer, hypertension and weak immune systems on the rise, dairy may offer diet-based solutions. There is enough published evidence to suggest that milk and dairy products are rich in healthy bioactive ingredients, many of which are buried inside the complex structures of dairy components. Therefore, a systematic mining of dairy may lead to the development of novel bioactive ingredients that can be used in a range of food products.

The most well-researched bioactive components in milk include colostrum, α -Casein, β -Casein, whey protein, α -lactalbumin, β -lactoglobulin, immunoglobulins, lactoferrin, lactoperoxidase, casein and whey protein hydrolysate. Figure 1 shows summarises general processing steps that can be used for fractionation of milk into bioactive ingredients and Table 1 outlines their potential health benefits.

In order to fractionate, isolate and concentrate bioactive components from milk, the first step is separation of fresh milk into cream and skim milk. The cream part contains almost all of the fat globules, and the associated fat globule membrane that is a rich source of several bioactive components (see Figure 1).

Skim milk is usually treated with acid or rennet to separate casein from whey proteins; both casein and whey streams then become raw materials for isolation of bioactive components. Although many biologically active peptide segments have been identified in casein (identified as casokinins),

the current commercial product range is limited to casein hydrolysates and phosphopeptides.

During cheese manufacture, part of κ -casein released in whey during rennet action is commercially available as glycomacropeptide (GMP). In the dairy industry, whey available from cheese manufacture remains the most abundant source of whey-based bioactive ingredients. Several bioactive ingredients can be commercialised from whey as shown in Figure 1. Among these are ingredients enriched in whole proteins (e.g. β -lactoglobulin, α -lactalbumin, lactoferrin and lactoperoxidase), hydrolysed forms of proteins (e.g. whey protein hydrolysates with varying degrees of hydrolysis), and milk minerals.

Colostrum

One of the most bioactive-rich fluids produced by the cow is the colostrum. Colostrum provides life-supporting immune and growth factors that ensure the health and vitality of the newborn and it is a rich source of several bioactive components, including immunoglobulins, lactoferrin, lactoperoxidase and lysozyme.

Colostrum contains over 10 times the amount of immunoglobulins present in normal milk. Immunoglobulins are very heat-sensitive proteins, which makes the processing of colostrum into an ingredient a difficult process.

Colostrum is also a rich source of growth factors. Growth factors are key regulators of a variety of cellular functions and are involved in the control of tissue growth and repair.

Extensive research has identified a number of applications for their use in clinical medicine and biotechnology. The most important of these is likely to be a therapeutic with potential in wound healing. China remains one the world's largest consumers of bovine colostrum, however, its use in infant formula was banned in 2012. This was mainly to prevent infant formulae being contaminated with low-quality colostrum products.

Whey proteins

Despite having been considered as a waste that pollutes the environment, whey has shown enormous potential as a result of its proteins and it has been used as a popular protein supplement in various functional foods. In fact, components from whey exhibit a number of functional, physiological and nutritional features that make them potentially useful for a wide range of medical food applications.

Research has shown that whey-derived components can reduce the risk of metabolic syndrome, which can lead to various chronic diseases such as cardiovascular disease and diabetes. Health problems associated with HIV, hepatitis B and osteoporosis have also been reduced, either directly or indirectly, by the use of whey derived components. Although whey protein concentrate and isolate are widely available, individual fractions have not been widely commercialised.

Whey protein's biological activities are partially attributed to specific peptides encoded in proteins, which can be obtained by enzymatic

hydrolysis of proteins. Whey proteins are also a source of branched-chain amino acids (BCAAs) such as leucine, isoleucine and valine. Leucine is known to be an important factor for tissue growth and repair. Whey proteins also contain high levels of sulphur-containing amino acids cysteine and methionine, which enhance immune function upon intracellular conversion to glutathione, a potent antioxidant.

Glycomacropeptide

Glycomacropeptide (GMP) is a hydrophilic peptide (amino acid residue 102 to 169) of κ -casein that provides stability to casein micelles in milk. When rennet acts on κ -casein during the manufacture of cheese, GMP is released into the whey. GMP makes up about 15 to 20 per cent of the whey proteins. GMP is unique among some of the whey proteins in that it is a glycoprotein so it has an oligosaccharide chain attached to it. It also is unique because it contains no phenylalanine, tryptophan or tyrosine.

A small percentage of the population has phenylketonuria (PKU), meaning they are unable to digest phenylalanine. GMP is one of the few amino- acid sources PKU patients can



tolerate because the pure GMP does not contain phenylalanine.

GMP also has high levels of the branched-chain amino acids, leucine, isoleucine and valine. Published research has linked GMP with many physiological functions, including: promotion of bifidobacterial growth; suppression of gastric secretions; inhibition of bacterial and viral adhesion; modulation of immune-system responses; and binding of cholera and E. coli enterotoxins. In simpler terms, GMP offers potential

benefits to intestinal health, appetite control, reduced dental caries, enhanced immunity and protection against diarrhoea.

Lactoferrin

Lactoferrin is an iron-binding glycoprotein present in colostrum, milk and whey. Lactoferrin can provide several physiological functional (bioactive) properties, which are mainly derived from its ability to bind iron. The main bioactive properties of lactoferrin include antibacterial and antiviral



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BIOACTIVE INGREDIENT	POTENTIAL BIOLOGICAL FUNCTION	POTENTIAL FOOD APPLICATIONS
Colostrum	Immune factors, growth factors, anti-microbial	Sports formulations, hospital and medical nutrition
α -Casein	Immunomodulatory, anti-microbial, mineral binding, opioid agonist/ antagonist, antioxidant, ACE-I	Enteral and adult medical nutrition
β -Casein	Immunomodulatory, mineral binding, antioxidant, ACE-I, opioid agonist, cytomodulation, mineral binding	
Whey protein	Anti-cancer, anti-hypertensive, immune enhancing, anti-bacterial, anti-viral, cholesterol reduction, anti-thrombic	Infant and adult medical nutrition, sports beverage, hospital meals
α -Lactalbumin	Sleep enhancement, ACE-I activity, immunomodulation, anti-microbial, opioid agonist, anti-cancer	Drinks and beverages
β -Lactoglobulin	ACE-I activity, opioid agonist, anti-microbial	Drinks and beverages
Immunoglobulins	Antibacterial and immune enhancing, passive immunity	Infant formula
Lactoferrin	Iron binding ability responsible for many functions such as bacteriostatic effect, cell growth promotion, antioxidation and iron delivery and absorption	Health supplements, supplements for the elderly or immune-compromised patients, functional foods and drinks, infant formulas, cosmetics and oral care products, supplements for recovery from gastrointestinal infections
Lactoperoxidase	Preservation effect. Bacteriostatic effect against Gram +ve bacteria and bactericidal effect against Gram -ve bacteria, e.g. pseudomonads, coliforms, salmonella, Listeria	Food preservation in general, meat products
Casein and whey protein hydrolysate	Reduced allergenicity, increased protein absorption, increased peptide bioactivity, lowering blood pressure	Infant and enteral formulation, geriatric products, sports beverages, weight control diets
Casein and whey peptides	Fast absorption of peptides. Non-allergenic source of proteins	Infant and enteral formulation, isotonic beverage, sports nutrition
Caseinophosphate (CPP)	Mineral carrier, helps in re-mineralisation and mineral absorption, protection against dental caries, antibacterial	High mineral beverages, chewing gum, breakfast cereals
Glycomacropeptide (GMP) or Caseinomacropeptide (CMP)	Satiety, low phenylalanine, branched chain amino acids	Dental care products such as toothpaste and mouthwash for prevention of dental caries and remineralisation. Supplements and diets for Phenylketonuric (PKU) sufferers. Prebiotic for probiotic supplements and foods. Sports nutrition products as source of branched chain amino acids. High protein diets for weight control
Milk minerals and milk calcium	Prevention of osteoporosis and growth of healthy bones and teeth, blood pressure and cardiovascular disease control, lower effect on hypertension, prevention of colon cancer, control of weight gain and obesity	Dairy products such as recombined milk, flavoured milk, yogurt and cheese. Nutritional and functional foods such as sports and adult nutritional beverages, weight loss products and sports bars. Bakery products such as breads and cakes, confectionery products and breakfast cereals. Convenience foods such as soups, sauces and frozen desserts and food supplements such as capsules and tablets.
Conjugated linoleic acid (CLA)	Tumour inhibition, immune modulation	Spreads, health foods and supplements
Bovine serum albumin (BSA)	Fatty acids binding, antioxidant, prevention of cancer	Adult and medical nutritional supplements
Phospholipids	Immune modulation, anti-infection, anti-tumour,	Infant formula, cholesterol lowering beverages and spreads
Osteopontins	Immune functions	Infant formula

properties, antioxidant properties, immune modulation, and ability to carry iron.

Lactoferrin inhibits the growth of pathogenic bacteria and fungi, due to its ability to bind large quantities of iron. Lactoferrin binds iron very strongly, thus rendering this essential nutrient unavailable to support microbial growth. Lactoferrin also disrupts bacterial digestion of carbohydrates, further limiting their growth. In addition, the action of pepsin in the stomach converts lactoferrin into lactoferricin, which has broad-spectrum activity against pathogenic bacteria and yeast. Lactoferrin also has the ability to bind to parasites and the outer membrane of Gram-negative bacteria, making the cell wall more permeable, thereby improving the efficiency of antibiotics.

Casein and whey protein hydrolysates

The enzymatic hydrolysis process produces protein ingredients designed for nutritional, dietetic and medical foods. Both casein and whey proteins can be hydrolysed to produce protein hydrolysates with variations in the degree of hydrolysis. Enzymatic protein hydrolysates containing short chain peptides with characteristic amino acid profiles and defined molecular size are used in specific formulations such as those used for feeding hospitalised patients.

Hydrolysis of cow milk proteins into smaller peptides reduces the risk of allergenicity and allows the use of hydrolysate as a substitute for human milk protein in infant formula. Milk protein hydrolysates are also suitable for replacement of intact proteins in adult nutritional formulations where reduced allergenicity is needed. Food applications that can benefit from reduced allergenicity are infant formula, adult nutritional formulations, isotonic sports, enteral formulations and medical nutritional formulations.

Milk minerals

Calcium and phosphorus are the major minerals required for the growth and development of bones and teeth. Calcium deficiency is far too common in diet, and awareness of this deficiency has led to calcium fortification of a range of food products including breakfast cereals and fruit juices. Although consumers consider milk and dairy products to be the richest sources of calcium, many have limited their consumption to reduce fat in their diets, or because of their intolerance to lactose.

Milk minerals are a rich source of calcium used for calcium fortification of food and beverage products. Commercial milk mineral complex is obtained from cheese whey after removal of proteins, which are converted into protein concentrates, and lactose, which is dried into lactose powder.

In summary, although milk contains bioactive components both in the lipid and in the skim part, by far, skim milk and whey are the major sources of bioactive components. To date, many of the bioactive components from milk remain unexploited as commercial ingredients. However, developments in new processing technologies and a desire to add value to dairy may stimulate further commercialisation of healthy bioactive components from milk. 🍌

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