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The Power of Colostrum: Understanding Cow's First Milk

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Abstract: Colostrum, the first milk produced by cows after giving birth, is a rich source of natural macro- and micronutrients, immunoglobulins, antimicrobial peptides, and growth factors. These components play a crucial role in the development of the newborn's immune system, providing protection against various gastrointestinal, respiratory, cardiovascular, and metabolic disorders. Colostrum also exhibits significant immunomodulatory and anticancer properties, with potential applications as an antiviral agent. This article reviews the composition of bovine colostrum, highlighting its fats, lipids, carbohydrates, proteins, vitamins, minerals, and bioactive components. Key factors such as immunoglobulins, cytokines, growth factors, and hormones contribute to colostrum's therapeutic effects on gastrointestinal health, immune function, skin conditions, bone density, and chronic diseases like diabetes and hypercholesterolemia. The potential of bovine colostrum as a functional food and therapeutic supplement for various health conditions is explored.

Keywords: Colostrum-Growth factor-Anti Microbialpeptides-Immune system-Diabetes-Skin condition-Therapeutic supplement

Introduction

The first milk a cow produces after giving birth is called colostrum (BC), and it contains a wealth of natural macro- and micronutrients, immunoglobulins, peptides with antimicrobial action, and growth factors.(1) It is a complex biological fluid that aids in the development of the newborn's immunity by including growth and immunological components. It has immunoglobulins, which function as organic antimicrobial agents to actively promote the immune system maturation of a newborn. Numerous GIT issues, respiratory conditions, cardiovascular conditions, and metabolic disorders are treated with it. As an immunomodulator and anticancer drug, colostrum demonstrates significant positive effects. Colostrum supplements have a significant deal of potential as an antiviral medication. The knowledge now available on the components of colostrum, such as proteins, carbohydrates, growth factors, enzymes, enzyme inhibitors, nucleotides, etc.(2)
The first historical mention of immunity dates back to the Athens epidemic in 430 BC, according to academics at the London School of Medicine (LSA). The immune system can be divided into two primary categories: innate and adaptive. Our first line of protection is our rapid and inbuilt natural defense mechanism, also referred to as innate immunity.(3)
Immunoglobulins and growth factors such as insulin-like growth factors (IGF, I and II), platelet-derived growth factor (PDGF), epidermal growth factor (EGF), transforming growth factor β-2 (TGF-β2), growth hormone (GH), and the cytokines interleukin 1-β (IL-1 β) are abundant in colostrum. These factors act as stimulants and mediators in numerous cellular processes. Numerous antibacterial, antiviral, antifungal, and immunoregulating compounds are included in it. Colostrum, the first nourishment of life, is created by the naturally occurring process known as "colostrogenesis" and is frequently referred to as "immune milk" or "liquid gold.".(4)

Constitute of Colostrum

Micro- and macronutrients

Fats and Lipids

The amount of fat in colostrum is higher than that of mature milk, and the makeup of these fats is different as well. Colostrum, which is primarily sold as protein products, is an excellent source of proteinaceous bioactive substances and vital nutrients. The lipid composition and thermal and physiological characteristics of milk are determined by the diameter of milk fat globules (MFG).(5) A biological membrane envelops milk fat globules (MFG), which are a source of lipids in milk . The diameter of MFG naturally varies between approximately 0.2 and 20 μm, and studies have indicated that the size of the distribution profile changes with the stage of lactation. These globules are crucial for distributing fat-soluble nutrients, bioactive compounds, and triacylglycerols (TAGs) to newborns.(6) By dispersing the fat in sucrose solutions at 4 degrees Celsius and fractionating by centrifugation over discontinuous sucrose gradients, fat globule membranes have been obtained from cow colostrum and cow milk.(7)

Carbohydrates

Lactose, oligosaccharides, glycolipids, glycoproteins, and nucleotide sugars are examples of carbohydrates in BC. Among the most significant bioactive elements in milk are glycoconjugates and oligosaccharides. Bovine oligosaccharides and glycoconjugates are probably suitable for usage as bioactive ingredients in milk products for

human consumption.(8) Numerous acidic oligosaccharides have been identified in colostrum, or the milk of both humans and cows.(9) The two carbohydrates were the recently discovered free forms of oligosaccharides from milk from mammals.(10) In both human and cow colostrum, lactose and oligosaccharides are the main carbohydrates. Milk oligosaccharides play a part in the development of intestine and brain cells and have anti-inflammatory, anti-adhesion, prebiotic, and glycome-modifying activities.(11)

Peptides and Proteins

Colostrum is a solution with a higher protein content and fewer carbohydrates than mature milk. It can be treated in a manner similar to that of mature milk to minimize fat content and modify the calorie density for specific nutritional purposes. Furthermore, because of their excellent protein digestibility and amino acid profile—particularly that of whey proteins—milk proteins are regarded as a "complete protein" source.(12) Glycosylated components found in the majority of colostrum and milk proteins have an impact on how well these proteins function. As these proteins transition from colostrum to mature milk through lactation, their glycosylation pattern also alters.The amount of glycosylated components in colostrum is larger than in mature milk, and it decreases dramatically over the first week of lactation. Against numerous strains, the glycoproteins found in colostrum have antiviral and antibacterial characteristics.(13)

Vitamins and Minerals

Vitamin A, including retinal, retinoic acid, retinol, retinyl ester, and beta-carotene, is the main vitamin metabolite found in bovine colostrum. Vitamin D, E, and F are the fat-soluble vitamins; vitamins B and C are the water-soluble vitamins.(4) Vitamin A is essential for growth and development, and vitamin E is needed to shield the baby from oxidative stress. Additionally, these nutrients are necessary for the young person's immune system to function properly.(14) Colostum contains non-enzymatic antioxidants such as copper, zinc, selenium, lactoferrin, vitamin E, A, and C, among others. Water soluble vitamin C is found in the cytosolic layer of cells.(15)the B complex vitamins, which include biotin, thiamine, riboflavin, niacin, pantothenic acid, pyridoxine, vitamin B12, and folic acid. Although the vitamins don't share any molecular similarities, they are grouped together due to their shared function in metabolism.(16)

Bioactive Component

Antimicrobial Factors

Immunoglobulins

A significant part of the immune activity present in colostrum and milk is composed of immunoglobulins. A variety of products from the bovine mammary gland that have been tested against a number of human diseases are referred to as "immune milk." the application of milk or colostrum as an immunoglobulin source. The newborn's gastrointestinal tract is then exposed to the immunoglobulins. The immunoglobulins are still sufficiently stable to offer the newborn protection benefits even if the environment is primarily designed to aid in digesting and obtain nutritional benefits.(17) The amount of colostrum produced at the first milking following calving and the amount of immunoglobulin (Ig) in the colostrum were shown to differ significantly between breeds.(18)

Colostrum contains immunoglobulin G (IgG), which is essential for the newborn calf's immune system defense and disease resistance.(19) Immunoglobulin G (IgG) , immunoglobulin A (IgA), and immunoglobulin M (IgM) are the three most significant Ig in cow colostrum. Cattle colostrum mostly consists of IgG, which makes about 85–95% of the total Ig concentration. IgG1 predominates in colostrum, while IgG2 is present at much lower levels.(20)

IgG may neutralize experimental infections of human cells, bind to a variety of human pathogens and allergens, and reduce gastrointestinal irritation. It is well recognized that a variety of components related to immunological development can be found in both human and cow's milk. Antimicrobial proteins include lysozyme, lactoperoxidase, and lactoferrin, extracellular vesicles like exosomes, and prebiotic oligosaccharides are all found in milk. The components of cow's milk have definite functional impacts on the human immune system.(21) Because the immunoglobulins are delivered from the serum into the mammary gland in a selective manner, the first colostrum has extremely high immunoglobulin concentrations.(22)

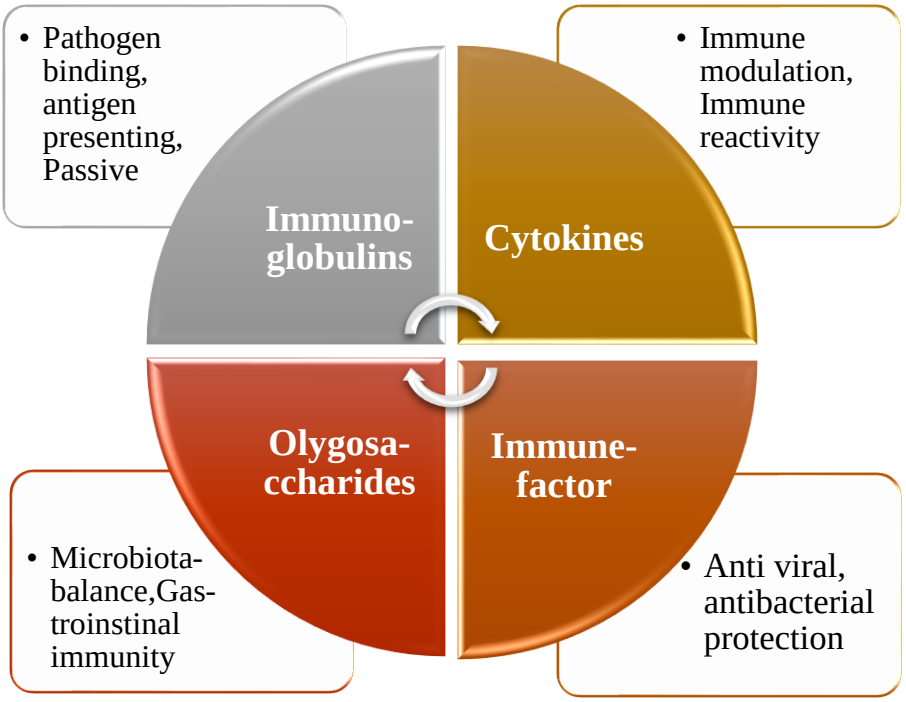

Figure-1 **Colostrum containing immune system and anti microbial avtivity(1)**

Cytokines and Immune Regulators

These consist of antimicrobial proteins and peptides including lactoferrin, defensins, and cathelicidins, as well as cytokines. Mammary epithelial cells secrete many innate immune effector chemicals, which aid in the host defense.(23) Human colostrum also included cytokine inhibitors, including soluble TNF-α receptor I and II and IL-1ra. Colostrum is thought to include a range of cytokines and serve as a great source of nutrition for newborns as well as a potential supply of immunomodulatory chemicals. TNF-α, INF-γ, IL-1β, and IL-6 are critical immune response mediators to infection and stress.(24)

High amounts of cytokines are seen in cow colostrum, and these cytokines are thought to play a key role in promoting the immune system's maturation in neonates.(25) With the exception of mammary-derived TNF-α and TGF-β1, all cytokines were found in colostrum/milk and linked with amounts in sow serum. These cytokines in breast secretions probably have an impact on how the newborn immune system develops.(26)

Growth Factors

The primary growth factors found in cow's milk and colostrum are EGF, BTC, IGF-I, IGF-II, TGF-b1, TGF-b2, FGF1 and 2, and PDGF. Although in smaller amounts, human milk also contains all of these development nutrients.(27) The concentration of growth factors can differ based on where they originate from. Numerous peptide growth factors that support the growth and differentiation of mammalian cells can be found in both colostrum and ordinary milk.(28) growth factors such as insulin-like growth factors (IGF, I and II), platelet-derived growth factor (PDGF), epidermal growth factor (EGF), transforming growth factor β-2 (TGF-β2), growth hormone (GH), and the cytokines interleukin 1-β (IL-1 β) are abundant in colostrum.

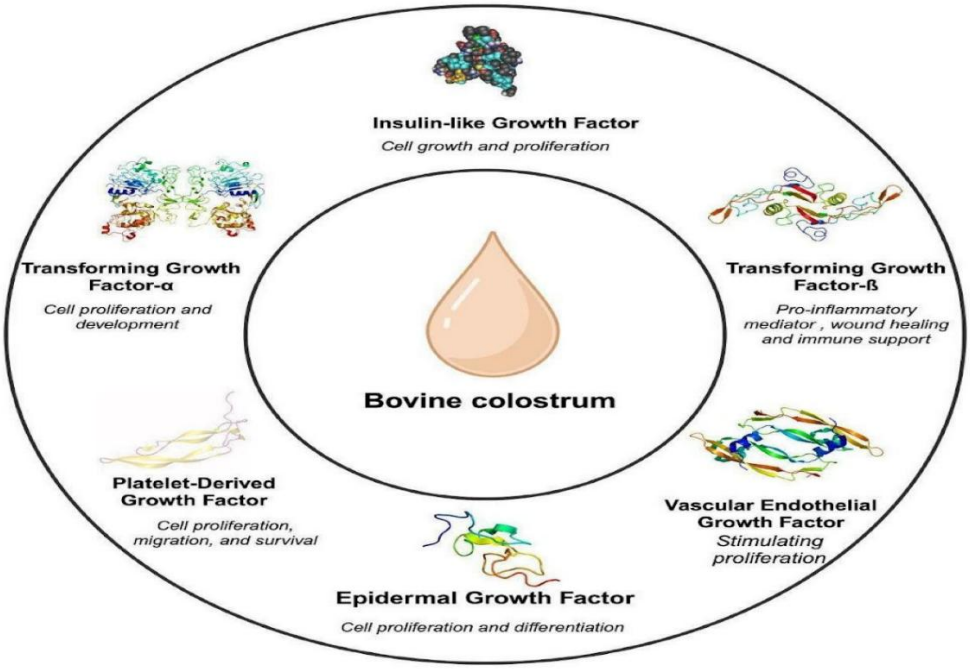

Figure-2 Growth Factor in bovine colostrum(28)

Epidermal Growth Factor

Despite the fact that EGF has been found in human milk at concentrations of up to 50 ng/ml (11), the growth factor composition of bovine milk was found to differ significantly from that of human milk, despite the fact that human milk and bovine milk have similar compositions and comparatively high concentrations of EGF.(29) EGF present in human colostrum or BC within the gut lumen may be able to access basolateral receptors within the developing newborn gut, which may help prevent bacterial translocation and promote gut growth in nursing neonates.(1)

Transforming growth factor α & β

TGF-α administered systemically has a number of effects, such as lowering the generation of stomach acid, raising the production of gastric mucus, and promoting the growth and repair of the gut.(1)Transforming growth factor (TGF)-β-like activity has been found in bovine colostrum. This activity is present in early colostrum at high levels. Its activity was entirely eliminated by a particular anti-TGF-β2 antibody.(31)

Platelet derived growth factor

Platelet-derived growth factor (PDGF) and the primary growth factor found in cow colostrum appear to share comparable biochemical properties.(31) Platelet-derived growth factor (PDGF) is a growth factor that is initially found in platelets, although macrophages can also manufacture and secrete it.(1) Mol. wt.forms of human PDGF, a highly cationic and hydrophobic protein, have been observed to range from 27,500 to 35,000. After being released from platelets when blood vessels are damaged, PDGF is expected to have a function in normal tissue repair processes. Studies conducted over the past 13 years have established PDGF as a growth factor of great interest.(32)

Insulin-like growth factor

IGF-I is an anabolic factor that promotes protein accumulation, and it is likely involved in mediating the growth-promoting actions of growth hormone. IGF-I and-II have been shown to survive exposure to both acid and heat, so it is likely that they remain biologically intact during commercial milk processing as well as during passage through the stomach.(1) Supplementing with colostrum may raise plasma IGF-I concentrations, which can directly affect tissue growth, or IGF-I may promote intestinal maturation and subsequent nutrient absorption.(33)

Bovine colostrum has almost five times greater IGF1 levels than mature milk. Colostrum, when combined with the milk that is subsequently generated, is essential for the nourishment, development, and growth of the newborn. It also strengthens the newborn's immune system, helps to fight off illness, and promotes the development of the neonatal gastrointestinal tract.(34) In biological fluids, IGF-1 is typically bound to its binding proteins (IGFBP); this has also been shown in the case of bovine milk. IGF-1 is inactivated by certain binding proteins, activated by others, and some binding proteins have their own biological activity.(35)

IGF-I feeding had no effect, while colostrum extracts caused minor intestine effects, indicating that many bioactive components rather than a single one were involved. Neonates' systemic alterations in their endocrine and metabolic profiles are contingent upon the kind, quantity, timing, and length of colostrum feeding.(36) IGF-1&2 are thought to function locally as paracrine and autocrine growth factors as well as as endocrine hormones through

the circulation. They also promote cell proliferation. Bovine colostrum contains a significant amount of IGF-I, which has more biological potency than IGF-II.(37)

Hormones

Prolactin, somatostatin, oxytocin, luteinizing hormone-releasing hormone, thyroid-stimulating hormone, thyroxine, calcitonin, estrogen, and progesterone are among the hormones found in BC.(1) The hormones in milk are produced by the mammary gland through an active transport process that starts in the blood flow. The mammary gland has the ability to manufacture some hormones and expel them as milk.(38)

Bovine colostrum contains a variety of hormones among its bioactive ingredients and functional components. It has been noted that these hormones released from blood flow and the mammary gland are crucial for the growth and maturation of the postneonatal gastrointestinal tract and the infant immune system. These hormones control some endocrine glands' activity temporarily until the baby's own hormonal system develops. Therefore, it is generally accepted that the growth and postneonatal health of newborn mammals, including humans, depend on the right hormones from the mother's milk.(39)

Colostrum used in various disease

Human Gastrointestinal (GI) Health and Disease

Targeted immunoglobulins are abundant in hyperimmune bovine colostrum (HBC), which is created when a cow is vaccinated during pregnancy and can be used to treat a number of illnesses. The documented history of using HBC to treat human gastrointestinal tract illnesses.In certain communal care settings, among tourists and military people, as well as in underdeveloped nations, diarrhea in young children is frequently caused by Shigella species, which is the cause of shigellosis. Although immunological methods, such as HBC, have been studied for both therapy and prevention, antibiotics remain the standard of care.(40)

The immune components found in colostrurm provide defense against these pathogens. Trypsin inhibitors are found in colostrum, which travels down the colon unaltered and supports the immune system and the integrity of the intestinal mucosa. Infections with bacteria, viruses, protozoa, and fungi can cause diarrhea. Because the BC contains certain antibodies, it can provide protection against enteric illnesses.(41)

Colostrum contain many immunomodulating components, which preserve and restore gastrointestinal tract health, are primarily responsible for its advantageous effects on gastrointestinal problem prophylaxis and therapy. Consuming colostrum may lessen the frequency and intensity of digestive issues including diarrhea and relieve inflammatory bowel disease, according to a number of studies. Additionally, it can help prevent and treat constipation, short bowel syndrome, and colon issues.(42)

Numerous GI disorders, including necrotizing enterocolitis, NSAID-gut injury, and inflammatory bowel disease, have been linked to dysbiosis. Moreover, multiple animal models of GI disorders have indicated that BC favorably modifies the gut microbiome and promotes healing, pointing to a causal relationship.It is commonly known that when human newborns are breastfed instead than formula fed, their gut microbiota is dominated by Bifidobacterium species and contains fewer Enterobacteria. (1)

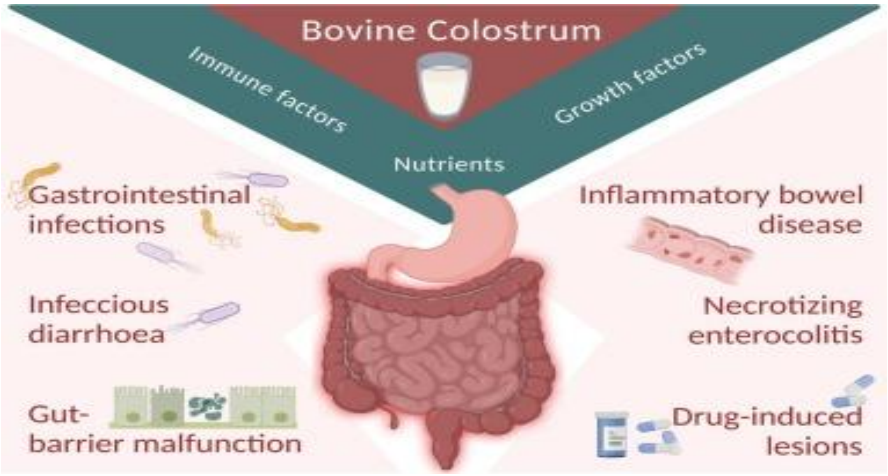

Figure-2 Colostrum component is used in various GI disease(42)

Colostrum and Skin

bovine colostrum-derived exosomes on keratinocytes, melanocytes, and fibroblasts—the three main resident skin cells—and UV-induced aging and damage. Colostrum exosome therapy stopped UV-induced intracellular reactive oxygen species production in epidermal keratinocytes.Both internal (genetics) and external (mental stress, diet, gut microbiota, air pollution, and UV exposure) variables contribute to skin aging.(43) Depending on the kind of

lesion, acne can be classified as either noninflammatory (only pimples) or inflammatory (mild pimples, scarring pimples, and nodular). Depending on how bad it is, acne can be classified as mild, moderate, or severe.(44) Benefits from subcomponents of BC have also been demonstrated; topical lactoferrin treatment, for instance, decreased inflammation in human volunteers exposed to local skin allergens.(1)

Specifically, ultraviolet radiation is the most frequent environmental stressor that ages and damages skin cells; in extreme situations, it also functions as a mutagenic agent that causes cutaneous cancer. characteristics of colostrum for the management of skin conditions marked by modified barrier function and altered differentiation.Not only in two-dimensional (2D) skin equivalents, but also in a more physiological system of three-dimensional (3D) skin equivalents, is bovine colostrum capable of promoting keratinocyte stratification and terminal differentiation.(45)

Colostrum and Immune Function in Health and Disease

The innate immune system is responsible for some of the components found in cow colostrum, such as antimicrobial peptides with compounded antibacterial properties like lactoferrin and lactoperoxidases.5. Glycoprotein lactoferrin possesses lipopolysaccharide-binding, antiviral, and growth-regulating properties. A variety of gram-positive and gram-negative bacteria have been demonstrated to be susceptible to the antibacterial enzyme lactoperoxidase, which also has antiviral properties. It works by blocking bacterial metabolism.(46)

Colostrum's primary purposes include providing the body with vital nutrients that boost immunity, inducing an immunological response, preserving gut microbiota, and hastening tissue regeneration.(47) Additionally, studies have indicated that BC supplementation can prevent diarrhea episodes and upper respiratory tract infections (URTIs) in children. It would be beneficial to conduct more research on how well BC works to boost immune function in various age groups and affect susceptibility to URTIs and other infections.(1)

Colostrum used in Bone Density

In cell culture, the use of bovine colostrum instead of serum promotes the proper proliferation of several cell types, including smooth muscle, fibroblasts, and epithelial cells. Colostrum is thought to include substances that may have anabolic effects on bone.(48) Supplementing with bovine colostrum has been shown to enhance human bone health. Low bone mass and micro-architectural degradation of bone tissue are the hallmarks of osteoporosis, a systemic skeletal disease that increases the risk of fracture and bone fragility. Exosomes that have been separated from cow colostrum may hold promise for improving bone remodeling, inhibiting bone resorption, and preventing osteoporosis.(49)

Colostrum used in Diabetes, Hypercholesterolemia,Cancer

The prevention and treatment of neurological disorders (such as dementia, cognitive decline, Parkinson's disease), and Alzheimer's disease-Alzheimer's disease is a neurological condition that worsens with time and results in atrophy, or the shrinking of the brain, and neuronal death.(50), cardiovascular diseases, immune system-related conditions, allergy issues, skin disorders, inflammatory bowel disease, gut microbial symbiosis, type 2 diabetes, and enhanced athletic performance are among the many conditions for which BC supplements are recommended. Compared to people with normal blood lipid profiles, those with hypercholesterolemia have a threefold increased risk of heart attacks. The World Health Organization (WHO) reports that cancer is the second leading cause of death globally, with distinct cancer kinds having differing effects on men and women.(51) According to WHO guidelines, diets high in fat, salt, and free sugar and deficient in fruits, vegetables, and complex carbohydrates raise the risk of cardiovascular illnesses.(52) Bovine colostrum used in Diabetes, Hypercholesterolemia,Cancer.

Conclusion

Colostrum is a nutrient-rich, bioactive substance produced by cows after giving birth. It contains a complex mix of macro- and micronutrients, immunoglobulins, peptides, growth factors, and bioactive components that significantly contribute to the growth, development, and immune defense of newborns. The presence of immunoglobulins and various growth factors in colostrum makes it an invaluable resource for promoting immune system maturation and protecting against a wide range of diseases. Colostrum have unique composition, including fats, carbohydrates, peptides, proteins, vitamins, minerals, and antimicrobial factors, plays a crucial role in numerous physiological processes. The bioactive components of colostrum have shown promise in the treatment and prevention of gastrointestinal disorders, respiratory conditions, skin health, bone density, diabetes, hypercholesterolemia, and even certain cancers. Additionally, the immunomodulatory and antiviral properties of colostrum make it a potential supplement for boosting immune function across different age groups.

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