The Multifaceted Applications of Lactoferrin in Health and Nutrition

Ameh Simon Sunday[1*]; Egwim Chidi Evans[1]; Muhammad Fatima Mahmoud[1]; Aboyeji David Oyeyemi [2,3]; Blankson Adenike Tinuke[1]; Alhassan Jibrin Dabban[1]; Onuekwusi Chukwuebuka Emmanuel[1]; Osisami Olubukunola Folashade[1,4]

[1]Department of Biochemistry, Federal University of Technology Minna, Niger State, Nigeria
[2]Department of Microbiology, Federal University of Technology Minna, Niger State, Nigeria
[3]African Centre of Excellence for Mycotoxins and Food Safety, Federal University of Technology Minna, Niger State, Nigeria
[1,4]Agricultural Biotechnology Development, National Biotechnology Research and Development Agency, NBRDA, Umaru Musa Yar'adua Express Way, Lugbe, Abuja, Nigeria

Corresponding Author: Ameh Simon Sunday*

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Abstract: Lactoferrin, an iron-binding glycoprotein predominantly found in milk, has gained significant attention for its diverse roles in health and nutrition. This review explores the multifaceted applications of lactoferrin, emphasizing its pharmacological benefits, nutritional properties, and potential therapeutic uses. In biomedicine, lactoferrin exhibits antimicrobial, antiviral, and anti-inflammatory activities, playing a crucial role in immune modulation and gut health. Its ability to enhance iron absorption and support microbiota balance positions it as a valuable dietary supplement in nutrition. Additionally, the incorporation of lactoferrin into functional foods and beverages offers promising avenues for improving public health outcomes. This review aims to synthesize current research on lactoferrin's mechanisms of action, its applications in clinical and dietary contexts, and future directions for research and development. By highlighting the importance of lactoferrin in both health and nutrition, this review underscores its potential as a key component in preventive healthcare strategies.

Keywords: *Lactoferrin, Glycoprotein, Nutrition.*

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I. INTRODUCTION

Lactoferrin is a multifunctional glycoprotein primarily derived from milk, particularly colostrum, and is also present in various bodily fluids such as saliva, tears, and mucus [1]. Known for its iron-binding capacity, lactoferrin plays a significant role in several biological processes, including immune response, inflammation regulation, and microbial defense. Its unique properties have attracted considerable interest from researchers and healthcare professionals alike, leading to a growing body of literature that explores its applications in health and nutrition [2].

In the biomedical field, lactoferrin has demonstrated substantial potential as a therapeutic agent. Studies have shown its efficacy in modulating immune responses, reducing the severity of infections, and promoting gut health by maintaining a balanced microbiome.

In the area of nutrition, lactoferrin is increasingly recognized for its functional benefits. As a natural supplement, it enhances iron absorption, making it particularly valuable for populations at risk of iron deficiency, such as pregnant women and young children. Additionally, the incorporation of lactoferrin

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into fortified foods and beverages has emerged as a promising strategy to improve dietary quality and health outcomes [3].

II. BACKGROUND

Lactoferrin is a member of the transferrin family of proteins and is characterized by its high affinity for iron, which is crucial for various biological functions. First discovered in the early 1930s, lactoferrin has since been recognized for its multifaceted roles beyond iron transport. As interest in functional foods and dietary supplements rises, lactoferrin stands out as a promising candidate for enhancing health and nutrition [4].

Lactoferrin's role in nutrition is underscored by its ability to enhance iron bioavailability, making it an essential component in combating iron deficiency anemia, a prevalent global health issue. Its incorporation into functional foods and dietary supplements has gained traction, as it offers a natural means of improving nutrient absorption and overall health [5].

III. APPLICATION IN FOOD INDUSTRY (INFANT FORMULA)

A healthy diet from infancy is crucial since it can affect adult health in the long run [6]. When compared to newborns fed artificial formula, breastfed babies typically show better health results, including variations in gut microbiota composition, nutritional status, and even cognitive development and IQ [7].

Human milk contains lactoferrin (Lf), which may improve the gastrointestinal barrier. Lactoferrin increases intestinal epithelial cell proliferation and decreases permeability, according to both in vivo and in vitro research on cell lines [8]. Research has indicated that a lactoferrin-enriched newborn formula (850 mg/L) was more beneficial and well-tolerated than a typical formula made from cow's milk (102 mg/L). During the first six months of life, infants fed the enriched formula showed better hematocrit levels, a decreased incidence of lower respiratory tract infections, and increased weight gain [9].

IV. APPLICATIONS IN FUNCTIONAL FOODS

In addition to its well-known use in baby formula, Lf is now more frequently found in a wide range of other food items, such as yogurts, dietary supplements, skim milk, drinks, and pet food [10]. Growing interest in Lf's multifunctional bioactivity, especially its immunomodulatory, antibacterial, and antioxidant properties, which may enhance the nutritional profile and functional value of common foods, is shown in this diversification.

One such example is the addition of 100 mg of Lf to yogurt, which was linked to a decrease in preschoolers' vomiting-related absences. However, the lack of a precisely defined control group in this investigation limited the interpretation of causality. Whether the advantages were due to Lf alone, the probiotic lactic acid bacteria, or a possible synergistic effect between the two is yet unknown. It is interesting to note that adding lactoferrin to yogurt does not change the produce's structural integrity or its physicochemical characteristics when it is being refrigerated [11].

Lf-enriched yogurt has shown several physiological advantages in addition to its stability in dairy matrices. These include demonstrated antibacterial actions against a range of microorganisms, enhanced intestinal transit, and enhanced antioxidant activity [12].

V. BIOMEDICAL APPLICATION OF LACTOFERRIN (ANTIBACTERIAL ACTIVITY)

Lactoferrin has been shown to be an intriguing chemical in pharmacological research against strains of bacteria that are resistant to many drugs. It also exhibits activity against a wide range of pathogenic microorganisms, including protozoa [13]. Research has turned to innate immune system proteins like Lf, for which no bacterial resistance has been found, to combat bacterial strains' resistance to commercial medications [14].

One bacteriostatic and one bactericidal (iron-independent) mechanism of action underlie Lf's antibacterial activity (against both gram-negative and positive bacteria) [15]. Because Lf may sequester iron by removing it from the bacteria that require it for growth and proliferation, it demonstrated bacteriostatic action. Bacterial growth resumes when exogenous iron is added in excess of Lf's binding capability [13].

Other mechanisms that underlie Lf's antibacterial activity have also been reported, including the induction of death in infected cells and the bactericidal activity of PMNs, as well as the inhibition of adhesion and colonization, which prevents biofilm formation [13]. Bacterial cells can be inhibited or killed by Lf by direct action, immune system stimulation, cytokine and chemokine production, or accelerated immune system cell maturation [16].

By binding to anionic molecules on the bacterial surface, such as lipoteichoic acid, LF's mechanism of action against Gram-positive bacteria reduces the negative charge on the cell wall, favoring contact between lysozyme and the underlying peptidoglycan over which it exerts an enzymatic effect [17]. Studies conducted both in vitro and in vivo have demonstrated that LF can stop some bacteria from adhering to the host cell [18]. Although the exact mechanisms preventing attachment are unknown, it has been proposed that LF's oligomannoside glycans bind bacterial adhesins and stop them from interacting with host cell receptors [19].

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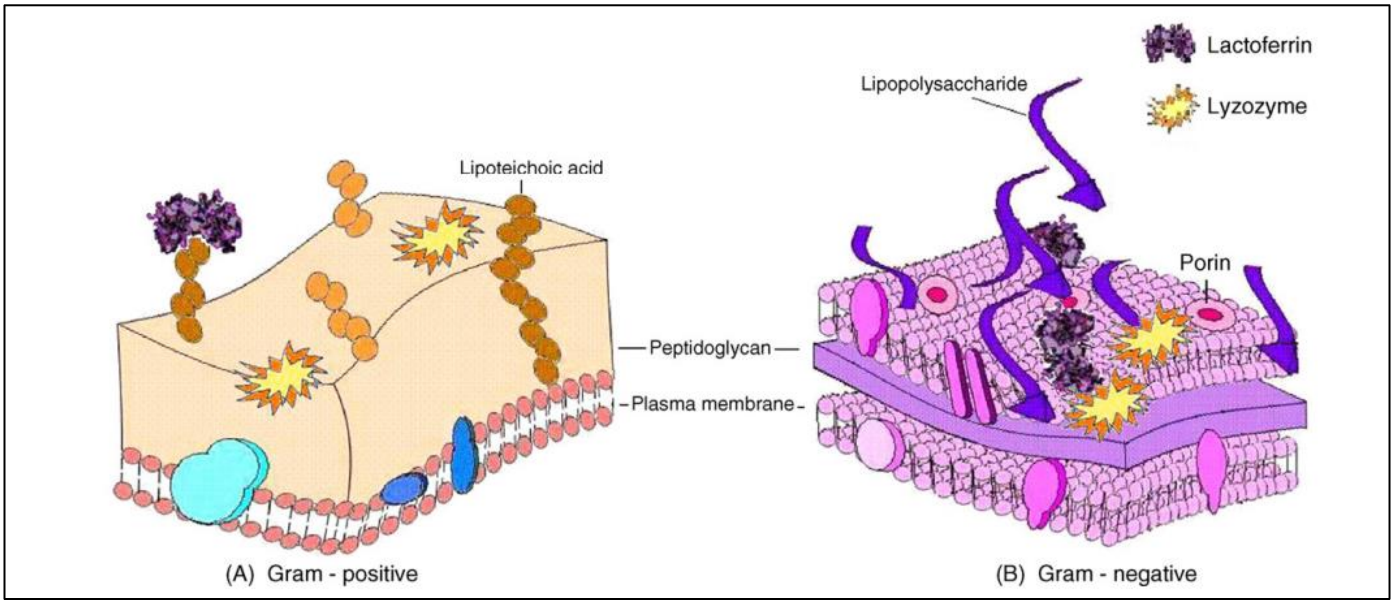

Fig. 1 Mechanism of Antibacterial Action of Lactoferrin (LF). (A) Gram-Positive Bacteria: LF is Bound to Negatively Charged Molecules of the Cell Membrane such as Lipoteichoic Acid, Neutrali Sing Wall Charge and Allowing the Action of Other Antibacterial Compounds such as Lysozyme. (B) Gram-Negative Bacteria: LF can Bind to Lipid A of Lipopolysaccharide, Causing Liberation of this Lipid with Consequent Damage to the Cell Membrane.

VI. ANTIVIRAL PROPERTIES

Lf inhibits infection in both people and animals and possesses antiviral activity against naked or enveloped viruses. Its antiviral activity stems from its synergistic action against certain antiviral medications like acyclovir, ribavirin, or zidovudine [20]. However, it also contributes to the early stages of viral infection by either binding directly to the virion's surface (by binding to virus envelope proteins) or by binding and blocking the cellular receptors that the virus would use to adhere to it and enter host cells [21].

Because Lf binds to the ACEII receptor on cells, which the virus uses for anchoring, it has antiviral efficacy, for instance, against SARS-CpV-2. Lf stops the virus from penetrating the cells by inhibiting the receptor [22]. Because it can stop the function of caspase3, a protease that is essential for controlling apoptosis, it also shows activity against the influenza A virus. Lf regulates the apoptosis of infected cells in this manner [21]. By directly interacting with the HCV virus, the causative agent of cirrhosis and hepatocellular cancer, human and bovine lactoferrin has been demonstrated to inhibit infection of lymphocytes and hepatocytes (Hara et al. 2002). In particular, a region of bovine lactoferrin formed from amino acids 600–692 called C-s3 is able to interact with viral glycoproteins E1 and E2. The same mechanism of action has been shown against HBV [21].

Lf also plays a role in preventing infection of herpes simplex viruses 1(HSV1) and herpes simplex viruses 2(HSV2) by binding to heparan sulfate and chondroitin sulfate glycosaminoglycans present on cell membranes. Lf and lactoferricin also have activity against HIV1 and HIV2 due to their globular structure and negative charge (characteristics required for antiviral action against these viruses) [21].

LF's antiviral mechanisms are still unknown. LF can prevent several viruses, including CMV, herpes simplex virus types I and II, and poliovirus type 1, which causes poliomyelitis in humans, from internalizing into the host cell [23]. LF suppresses viral replication in the host cell instead of blocking entry for other viruses, such as rotavirus and hepatitis C virus (HCV) [24]. The antiviral properties of LF have been attributed to a number of different modes of action. The idea that LF binds to and inhibits glycosaminoglycan viral receptors, particularly heparan sulfate (HS), is one of the most widely accepted theories [25]. By preventing the first interaction between the virus and the host cell, the binding of LF and HS stops the infection. The antiviral effect of LF has also been observed in viruses that infect animals, such as the Friend virus complex, which causes erythroleukaemia in rodents, the feline calicivirus and feline immunodeficiency virus [26].

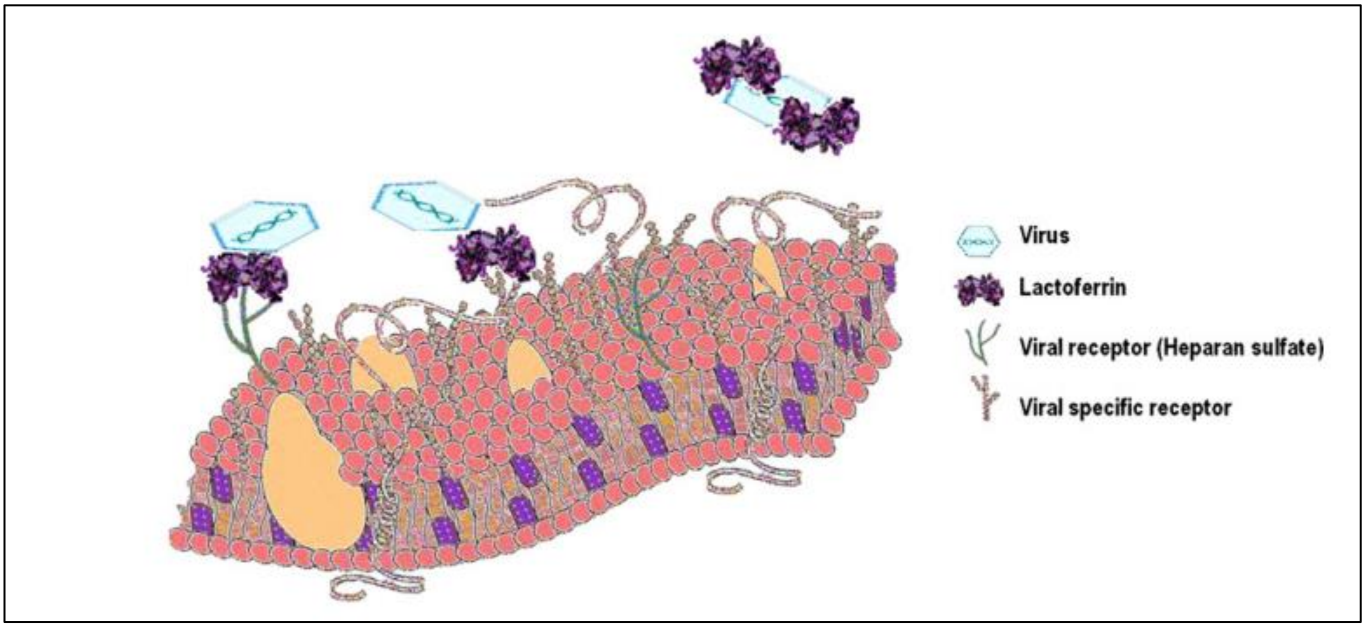

Fig. 2 Mechanism of Antiviral Action of Lactoferrin (LF). LF can be Linked to the Viral Particle and to Glycosaminoglycans, Specific Viral Receptors or Heparan Sulfate to Prevent Internalisation of the Virus into the Host Cell.

VII. ANTIPARASITIC ACTIVITY

One of the main causes of diarrhea in children under five and the fourth most common cause of death worldwide is intestinal amoebiasis, which is brought on by a protozoan infection [27]. The illness is brought on by Entamoeba histolytica, which causes amoebic colitis by invading the intestinal mucosa through intricate pathways. Because it may bind the lipids on the trophozoite's membrane, producing membrane disruption and harm to the parasite, apo-LF is the milk protein that has the strongest amoebicidal impact against E. histolytica in vitro [28]. The intracellular parasite Toxoplasma gondii, which causes toxoplasmosis in both people and animals, can be bound by hLF, according to additional in vitro research [29]. However, LF cannot prevent the parasite from entering the host. Its mechanism of action in this case is inhibition of intracellular growth of *T. gondii* within host cells.

VIII. ANTI-CANCER ACTIVITY

Recent research has revealed that Lf can also be utilized as a carrier for chemotherapeutics and, because it can pass through the blood–brain barrier, to treat brain tumors [30]. This may be connected to the fact that Lf can either accelerate cell division and migration on healthy normal cells or prevent it on cancer cells [31].

Lf can inhibit or stop the growth of cancer cells in a number of ways, including by triggering the adaptive immune response, reducing the expression of growth factor protein (such as vascular endothelial growth factor protein in the human lung cancer cell line—A549 (Tung et al. 2013)), increasing the expression of surface receptors on neoplastic cells (which helps the immune system identify them), and inhibiting angiogenesis and the growth of blood vessels to the tumor [31].

The Lf cytotoxicity towards cancer cells is related to cell cycle arrest, cell membrane damage or induction of apoptosis of dangerous cells [31]. It has been proposed that the anticancer effect is due to two different processes: cell signalling and recognition through the glycans that make up its structure or the interaction of proteoglycan, glycosaminoglycan, and sialic acid with Lf. These mechanisms can also explain the selectivity of Lf against cancer cells and not on healthy cells [32].

Lf can be used for a lot of different tumor, i.e., colon cancer, breast cancer or lung cancer. It was found, for example, that the oral administration of Lf on rats treated with azoxymethane decreased the occurrence of colon carcinogenesis: 0.2% or 2% respectively decrease of 32.5% and 42.5% [33].

IX. TREATMENT OF IRON DEFICIENCY

Over 2 billion individuals worldwide suffer from iron deficiency anemia (IDA), which is still one of the most common dietary deficits (Bathla and Arora, 2022). A special method of delivering iron is provided by lactoferrin, an iron-binding glycoprotein found naturally in milk and other secretions (Ashraf *et al.*, 2024). Lactoferrin promotes iron uptake through receptor-mediated endocytosis via lactoferrin receptors in the intestinal mucosa, in contrast to traditional iron salts that depend on passive absorption. With fewer gastrointestinal adverse effects, this focused delivery method may offer more effective iron transfer (Ianiro *et al.*, 2023).

X. APPLICATION OF LACTOFERRIN IN WOUND HEALING

Applications of lactoferrin in wound healing include boosting angiogenesis, the inflammatory response, fibroblast and keratinocyte activity, and granulation tissue production and re-epithelialization (Belvedere et al., 2021). Additionally, it has antibacterial qualities that help cure both normal and chronic wounds, including those in diabetic patients, by preventing infections and biofilms. To enable its direct administration to the wound site, lactoferrin can be included into topical solutions such hydrogel dressings (Takayama, 2011).

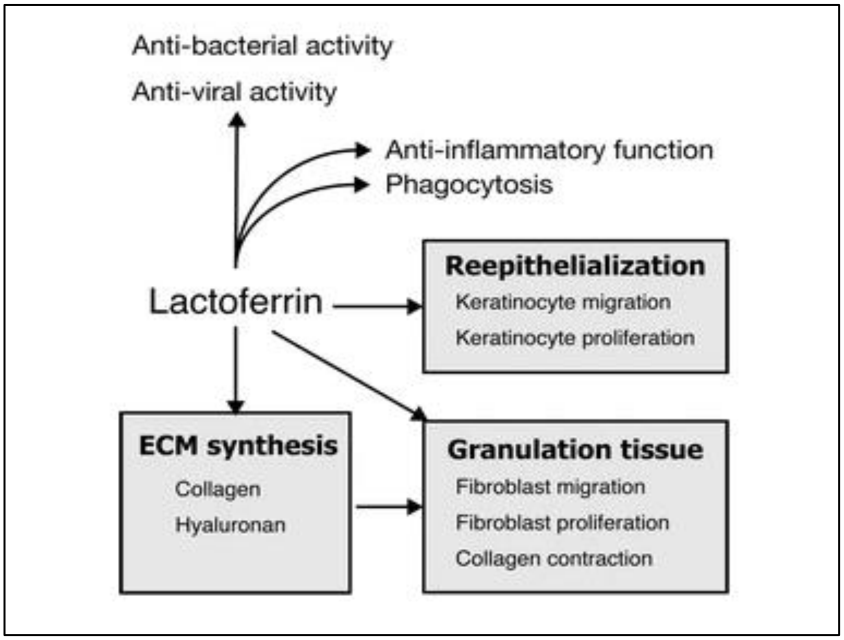

Fig 3: Effects of Lactoferrin on Normal Wound Healing

XI. CONCLUSION

Lactoferrin is a multifunctional bioactive protein that has important nutritional and health consequences. Its many uses range from improving gastrointestinal health and encouraging iron absorption to boosting immune function and demonstrating antibacterial qualities. Its promise as a therapeutic agent in a variety of medical problems, such as infections, inflammation, and chronic diseases, is highlighted by the expanding body of research. Lactoferrin's incorporation into dietary supplements and functional meals offers promising prospects for enhancing public health outcomes. All things considered, lactoferrin stands out as a promising element in the search for novel approaches to nutrition and health, meriting further research and use in both everyday and clinical contexts.

RECOMMENDATION

Because of its wide range of biological functions, lactoferrin should be more carefully included into frameworks related to nutrition, health, and food formulation. Its demonstrated antibacterial, anti-inflammatory, immunomodulatory, antioxidant, and iron-binding qualities demonstrate its promise as a useful component for enhancing human health at various phases of life.

From a nutritional perspective, lactoferrin should be added to newborn formulae, weaning foods, functional dairy products, and medical nutrition formulations, especially in areas where iron deficiency, infectious illnesses, and malnutrition are highly prevalent.

Lastly, to transform current scientific knowledge into useful applications, interdisciplinary cooperation between food scientists, nutritionists, doctors, and policymakers is advised. The sustainable production, availability, and efficient use of lactoferrin as a bioactive substance in advancing public health and nutritional security will all be facilitated by such cooperation.

REFERENCES

[1]. Shini, V. S., Udayarajan, C. T., & Nisha, P. (2022). A comprehensive review on lactoferrin: A natural multifunctional glycoprotein. *Food & function*, *13*(23), 11954-11972.
[2]. Kell, D. B., Heyden, E. L., & Pretorius, E. (2020). The biology of lactoferrin, an iron-binding protein that can help defend against viruses and bacteria. *Frontiers in immunology*, *11*, 550441.

[3]. Artym, J., Zimecki, M., & Kruzel, M. L. (2021). Lactoferrin for prevention and treatment of anemia and inflammation in pregnant women: a comprehensive review. *Biomedicines*, *9*(8), 898.
[4]. Chasteen, N. D., & Woodworth, R. C. (2024). Transferrin and lactoferrin. In *Iron transport and storage* (pp. 67-79). CRC Press.
[5]. Ashraf, M. F., Zubair, D., Bashir, M. N., Alagawany, M., Ahmed, S., Shah, Q. A., ... & Arain, M. A. (2024). Nutraceutical and health-promoting potential of lactoferrin, an iron-binding protein in human and animal: current knowledge. *Biological Trace Element Research*, *202*(1), 56-72.
[6]. Koletzko, B., Brands, B., Poston, L., Godfrey, K., & Demmelmair, H. (2012). Early nutrition programming of long-term health. *Proceedings of the nutrition Society*, *71*(3), 371-378.
[7]. Kariyawasam, K. P., Somaratne, G., Dillimuni, S. D., & Walallawita, U. (2025). Comparative Analysis of Breastfeeding and Infant Formulas: Short-and Long-Term Impacts on Infant Nutrition and Health. *Food Science & Nutrition*, *13*(9), e70788.
[8]. Zhao, X., Xu, X. X., Liu, Y., Xi, E. Z., An, J. J., Tabys, D., & Liu, N. (2019). The in vitro protective role of bovine lactoferrin on intestinal epithelial barrier. *Molecules*, *24*(1), 148.
[9]. Shahramian, I., Kalvandi, G., Javaherizadeh, H., Khalili, M., Noori, N. M., Delaramnasab, M., & Bazi, A. (2018). The effects of prebiotic supplementation on weight gain, diarrhoea, constipation, fever and respiratory tract infections in the first year of life. *Journal of paediatrics and child health*, *54*(8), 875-880.
[10]. Bakshi, S., Paswan, V. K., Yadav, S. P., Bhinchhar, B. K., Kharkwal, S., Rose, H., ... & Bunkar, D. S. (2023). A comprehensive review on infant formula: Nutritional and functional constituents, recent trends in processing and its impact on infants' gut microbiota. *Frontiers in Nutrition*, *10*, 1194679.
[11]. Zakaria, A. M., Zakaria, H. M., Abdelhiee, E. Y., Fadl, S. E., & Ombarak, R. (2020). The impact of lactoferrin fortification on the health benefits and sensory properties of yogurt. *Journal of Current Veterinary Research*, *2*(2), 105-112.
[12]. Lin, Y., Song, S., & Guo, H. (2025). Recent advances in synergistic effect of lactoferrin. *Current Opinion in Food Science*, 101285.
[13]. Orsi, N. (2004). The antimicrobial activity of lactoferrin: current status and perspectives. *Biometals*, *17*(3), 189-196.
[14]. Avalos-Gómez, C., Aguilar-Chaparro, M. A., Ríos-Castro, E., Marin-Flamand, E., Sánchez-Mendoza, A. E., & de la Garza, M. (2025). Differences between protein cargo in outer membrane vesicles released from Mannheimia haemolytica A2 in the presence and absence of bovine lactoferrin. *Journal of Proteomics*, 105550.
[15]. Roşeanu, A., Damian, M., & Evans, R. W. (2010). Mechanisms of the antibacterial activity of lactoferrin and lactoferrin-derived peptides.
[16]. Coccolini, C., Berselli, E., Blanco-Llamero, C., Fathi, F., Oliveira, M. B. P., Krambeck, K., & Souto, E. B. (2023). Biomedical and nutritional applications of lactoferrin. *International Journal of Peptide Research and Therapeutics*, *29*(5), 71.
[17]. Malanovic, N., & Lohner, K. (2016). Antimicrobial peptides targeting gram-positive bacteria. *Pharmaceuticals*, *9*(3), 59.
[18]. Eker, F., Duman, H., Ertürk, M., & Karav, S. (2024). The potential of lactoferrin as antiviral and immune-modulating agent in viral infectious diseases. *Frontiers in immunology*, *15*, 1402135.
[19]. González-Chávez, S. A., Arévalo-Gallegos, S., & Rascón-Cruz, Q. (2009). Lactoferrin: structure, function and applications. *International journal of antimicrobial agents*, *33*(4), 301-e1.
[20]. Berlutti, F., Pantanella, F., Natalizi, T., Frioni, A., Paesano, R., Polimeni, A., & Valenti, P. (2011). Antiviral properties of lactoferrin—a natural immunity molecule. *Molecules*, *16*(8), 6992-7018.
[21]. Gruden, Š., & Poklar Ulrih, N. (2021). Diverse mechanisms of antimicrobial activities of lactoferrins, lactoferricins, and other lactoferrin-derived peptides. *International journal of molecular sciences*, *22*(20), 11264.
[22]. Pietrantoni, A., Dofrelli, E., Tinari, A., Ammendolia, M. G., Puzelli, S., Fabiani, C., ... & Superti, F. (2010). Bovine lactoferrin inhibits influenza A virus induced programmed cell death in vitro. *Biometals*, *23*(3), 465-475.
[23]. Eker, F., Duman, H., Ertürk, M., & Karav, S. (2024). The potential of lactoferrin as antiviral and immune-modulating agent in viral infectious diseases. *Frontiers in immunology*, *15*, 1402135.
[24]. Brummerhop, A. S., Lee, C. T., Weltman, R., Tribble, G. D., van der Hoeven, R., Chiu, Y., ... & Wang, B. Y. (2024). Synergistic effects of antimicrobial components of the human-derived composite amnion-chorion membrane on bacterial growth. *Frontiers in cellular and infection microbiology*, *14*, 1472737.
[25]. Li, B., Zhang, B., Liu, X., Zheng, Y., Han, K., Liu, H., ... & Liu, X. (2022). The effect of lactoferrin in aging: role and potential. *Food & Function*, *13*(2), 501-513.
[26]. Demir, R., Sarıtaş, S., Bechelany, M., & Karav, S. (2025). Lactoferrin: Properties and potential uses in the food industry. *International Journal of Molecular Sciences*, *26*(4), 1404.
[27]. Memon, I. A., Jamal, A., Memon, H., & Parveen, N. (2009). Intestinal amoebiasis in children and its effect on nutritional status. *J Coll Physicians Surg Pak*, *19*(7), 440-443.
[28]. Reyes-López, M., Ramírez-Rico, G., Serrano-Luna, J., & de la Garza, M. (2022). Activity of Apo- Lactoferrin on pathogenic protozoa. *Pharmaceutics*, *14*(8), 1702.
[29]. Anand, N. (2024). Antiparasitic activity of the iron-containing milk protein lactoferrin and its potential derivatives against human intestinal and blood parasites. *Frontiers in Parasitology*, *2*, 1330398.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jan1036

[30]. Cutone, A., Rosa, L., Ianiro, G., Lepanto, M. S., Bonaccorsi di Patti, M. C., Valenti, P., & Musci, G. (2020). Lactoferrin's anti-cancer properties: Safety, selectivity, and wide range of action. *Biomolecules*, *10*(3), 456.

[31]. Bukowska-Ośko, I., Sulejczak, D., Kaczyńska, K., Kleczkowska, P., Kramkowski, K., Popiel, M., ... & Kowalczyk, P. (2022). Lactoferrin as a human genome "guardian"—An overall point of view. *International Journal of Molecular Sciences*, *23*(9), 5248.

[32]. Rascón-Cruz, Q., Espinoza-Sánchez, E. A., Siqueiros-Cendón, T. S., Nakamura-Bencomo, S. I., Arévalo-Gallegos, S., & Iglesias-Figueroa, B. F. (2021). Lactoferrin: A glycoprotein involved in immunomodulation, anticancer, and antimicrobial processes. *Molecules*, *26*(1), 205.

[33]. Coccolini, C., Berselli, E., Blanco-Llamero, C., Fathi, F., Oliveira, M. B. P., Krambeck, K., & Souto, E. B. (2023). Biomedical and nutritional applications of lactoferrin. *International Journal of Peptide Research and Therapeutics*, *29*(5), 71.