University of Thi-Qar Journal of agricultural research

Thi-Qar Journal of agricultural research

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)

https://iasj.rdd.edu.iq/journals/journal/issue/20226 https://doi.org/10.54174/utjagr.v13ii 108

Alpha-lactalbumin protein in milk: Nutritional Properties and Vital Role in Human Health : a Review

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I. Abstract

Whey protein (WPI) comes from cheese, casein, and Greek yoghurt. A major source of functional proteins and peptides for the worldwide food industry. We can separate α-La, a globular protein, from whey protein isolate (WPI) utilising methods such acid precipitation, gel filtration, and membrane separation. α-lactalbumin dominates breast milk whey, followed by lactoferrin and immunoglobulins. In cow's milk, β-lactoglobulin is the main protein. Babies can not get enough of the amino acids tryptophan and lysine, as well as other physiologically active peptides, from this food. Some studies have shown that improving gastrointestinal health, immunological responses, and development by adding certain proteins, such α-lactalbumin, which includes important amino acids, to infant formula may also boost the absorption of vital trace elements like zinc and iron. Babies who are given formula may reap benefits comparable to those who are breastfed thanks to all these perks. The production of functional meals makes use of α-lactalbumin, which contains several peptides that include antibacterial, antiviral, antioxidant, anticancer, immunomodulatory, and mineral-binding capabilities. The review focuses on the nutritional benefits and features of α-lactalbumin, and also delves into its prospective uses for infants.

Keywords: α-lactalbumin ,Nutritional Properties, Infant health

II. Introduction

Approximately 3–5% of the proteins in cow's milk and about 22% of the proteins in human breast milk are alpha-lactalbumin, a whey protein. However, beta-lactoglobulin is abundant in cow's whey but not in human breast milk (Lönnerdal *et al*., 2017; Tinghäll Nilsson *et al*., 2023).

Aside from immunoglobulins and lactoferrin, the most abundant whey protein in human breast milk is α-lactalbumin. Cow's milk contains three major whey proteins: beta-lactoglobulin, alpha-lactalbumin and immunoglobulins. Human breast milk does not include beta-lactoglobulin (Layman et al., 2018).

The alpha-lactalbumin of milk is one of the most significant elements in milk. It is formed by the epithelial cells of the mammary gland and forms lactose synthase when it complexes with the enzyme β-1,4-galactosyltransferase. This enzyme converts glucose and galactose to lactose. As it increases the overall amount of milk produced, lactose synthesis is thought to be crucial for milk production. This is because it creates an osmotic force which pulls water into the mammary gland. (Kamau et al., 2010; Lisak Jakopović et al., 2016)

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)

https://iasj.rdd.edu.iq/journals/journal/issue/20226 *https://doi.org/10.54174/utjagr.v13ii 108*

The α-Lactalbumin contains bioactive peptides and essential amino acids that play an important role in the nutrition of newborns. These amino acids include those containing sulfur, branched-chain amino acids and tryptophan, which is essential for infant development; availability on the market of α-lactalbumin makes it possible to rework infant formulae to obtain mini-formulae containing levels of α-lactoglobulin similar to those of breast milk. (Tinghäll Nilsson et al., 2023).

The water solubility and thermal stability of alpha-lactalbumin makes it a preferred protein supplement in foods. Its unique amino acid profile is also beneficial to adults, particularly with regard to brain function and sleep, and it is a good dietary supplement. Some of the other parts of α-lactalbumin that might be useful as dietary supplements include bioactive peptides that have prebiotic and antibacterial qualities, and the branched-chain amino acid leucine, which helps with protein synthesis in skeletal muscle. (Ponchon *et al*., 2024)

In addition to being rich in important amino acids, it contains a rich amino acid profile of which a number of amino acids (tryptophan, lysine, cysteine, and branched-chain amino acids (valine, isoleucine and leucine) are also relatively abundant. (Layman et al., 2018)

Clinical studies suggest that protein level in infant formula could be lowered, while simultaneously increasing α-lactalbumin, in order to maintain the same high plasma levels of essential amino acids as breastfed infants. (Nilsson et al., 2025)

Because of its distinct amino acid makeup, α-lactalbumin could be utilised in various ways. It can be incorporated into infant formula to provide properties similar to breast milk, as a supplement to promote digestive wellness and modulate neurological functions such as sleep and depression, and as a therapy for diseases such as muscular dystrophy, mood disorders and cancer. It's also hit the front page for its potential novel applications in cancer treatment and boosting the immune system. (Kamau et al., 2010)

Alpha-lactalbumin is the second most abundant protein in bovine whey protein isolates and concentrates, constituting 15-20% of the total protein in these products. It is thermally stable and highly soluble in water over a wide pH (2.0–9.0), suitable for use in beverages, emulsions, foams and gels. Furthermore, the properties of alpha-lactalbumin are ideal for many nutrition applications where high quality proteins are required, including medicinal foods, lactose-free and low carbohydrate foods, protein fortified drinks, and newborn formula. (Permyakov, 2020).

The inclusion of certain proteins in infant formula, such as alpha-lactalbumin (ALA), a protein that contains essential amino acids, could prove beneficial to the immune system, growth and digestive system of babies. This would also increase the zinc and iron absorption. All these benefits can make formula-fed babies healthy just like those who are breast-fed.(Loènnerd, 2014)

According to Salzano et al. (2021), the abundance of bioactive chemicals in buffalo milk, including α-lactalbumin, is the main reason for its impressive health advantages. In addition to contributing to the inhibition of cancer cell growth, these chemicals have antioxidant and anti-inflammatory characteristics. (D'Onofrio et al., 2020).

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The goal of this research is to assess the antioxidant and antibacterial properties of alpha-lactalbumin, bioactive compounds of alpha-lactalbumin, and the health promoting properties, as well as to evaluate the potential of using alpha-lactalbumin in the development of functional meal for infants.

Alpha-Lactalbumin Properties

Milk composition differs across species. Whey proteins make up a large portion of human breast milk. Acid precipitation of casein is a common method for separating the whey from cow's milk in cheesemaking (Table 1). While beta-lactoglobulin, alpha-lactalbumin, and immunoglobulins make up the bulk of cow's milk, the order of importance for whey proteins in human breast milk is different. Human breast milk does not include beta-lactoglobulin. With an amino acid sequence similarity of 74%, human and bovine alpha-lactalbumin are chemically similar. Katab& Doosh, (2017).

As a globular protein with 123 amino acids and a molecular weight of 14.2 kDa, alpha-lactalbumin has one site on its surface that may bind calcium, four disulphide linkages, and an electrochemical neutrality range of 4.2 to 4.6 pH. (Cuevas-Gómez et al., 2021).

Estimates put its concentration in the range of 1–1.8 g/l. This protein is present in milk at its usual pH level of 6.6 as a monomer. However, it forms polymers when it combines with other protein molecules at pH values below neutral. A and B are the two varieties of α-lactobilin, and their genetic origins are different. There are four disulphide groups in every molecule. The molecular weight of the protein is 14.176 and it comprises 123 amino acids. Lisak Jakopović et al. (2016) and Permyakov (2020) reported that α-lactalbumin is a necessary protein for the production of milk. It is synthesized by cells in the epithelial lining of the mammary gland and is responsible for the synthesis of lactose synthase, a complex that combines it with beta-1,4-galactosyltransferase. This enzyme converts glucose to lactose and galactose to lactose. Lactose synthesis is the basic process for milk production as it provides an osmotic effect that pulls the water into the mammary gland and thus increases milk volume (Kamau et al., 2010; Lisak Jakopović et al., 2016).

Romano et al. (2021) confirmed in their study that the fat soluble vitamins A, D, and E could be bound by the protein, α-lactalbumin. However, it has been demonstrated that this protein binds to hydrophobic bioactive chemicals such as retinol, genistein, kaempferol, curcumin and capsaicin in highly affinized areas for intracellular transport. Nanoparticles and microparticles made of protein are known to be good vehicles for transporting bioactive substances including antioxidants, functional lipids, vitamins, and peptides that are present in food. α-Lactalbumin solutions have nutritional and physical characteristics that are comparable to whey protein isolates. These include purity of taste, high water solubility in a broad pH range (2.0-9.0), and thermal stability, which makes them ideal for use in a variety of drinks. According to Lajnaf et al. (2017), it offers versatility in product formulation and is also helpful in developing emulsions, foams, and gels. Due to its high protein quality and several beneficial qualities, lactalbumin finds widespread usage in a variety of food products, such as medicinal foods, lactose-free meals, protein-fortified drinks, and newborn formula (Permyako and Berliner, 2000). Table 1 shows that casein makes up over 80% of the protein in cow's milk, while whey accounts for around 40% and the total protein is around 60%.

Table (1) Bovine and human milk whey and casein protein concentrations (Layman et al., 2018).

HUMAN MILK 0.95 g/100 ml					.BOVINE MILK 3.3 g/100 ml		
%	**Caseins 40%**	**%**	**Whey protein 60%**	**%**	**Caseins 80%**	**%**	Whey protein 20%
12	α casein s1	0	β lactoglobulin	40	α casein s1	52	β lactoglobulin
0	α casein s2	36	α lactalbumin	10	α casein s2	17	α lactalbumin
68	βcasein	17	Immunoglobulins	36	β casein	10	Immunoglobulins
20	k casein	6	Serm albumin	14	k casein	5	Serm albumin
		25	lactoferrin			1.5	lactoferrin
		ND	glycomacropeptide			12	glycomacropeptide
		10	other			2.5	other

Due to the fact that bovine alpha-lactose shares 72% of its sequence with human alpha-lactose, it is now widely added to infant formula to improve the health of formula-fed infants. As an allergen in infants, beta-lactoglobulin constitutes 9% of the protein in cow's milk, and its content in hypoallergenic infant formula is three times lower than in cow's milk (Ding *et al*., 2011). The α lactalbumin tetrapeptide segment 50-53 of α-LA, which was isolated by enzymatic hydrolysis of α-LA using pepsin and trypsin, was discovered by Tavares et al. (2011) to lower blood pressure in adult rats suffering from spontaneous hypertension.

Alpha-Lactalbumin: Infant Nutrition and Growth

In the almost a century since its inception, infant formula has undergone several formulation changes to mimic the nutritional profile of breast milk and to enhance the protein quality. Breast milk, on the other hand, has a unique bioavailable and digestible combination of nutrients and bioactive chemicals (Lien, 2003; Carr, L. E., 2021). Little is known about the ingredients in infant formula. It would be more reasonable to compare the development and growth of babies who are breastfed with those who are given formula. Infant formula that includes certain proteins, like α-lactalbumin, which contains essential amino acids, may enhance gut health, immune responses, and growth. It may also enhance absorption of vital trace elements, such as iron and zinc, which could give formula-fed infants benefits comparable to breast milk. (Loènnerdal, 2014)

Because of its exceptional protein content and special nutritional characteristics, breast milk is the best nourishment for babies. But there are times when you can not get your hands on breast milk, thus manufacturers came out with infant formulae. Babies who are breastfed are less likely to gain excess weight as infants and teens, and they are also less likely to develop cardiovascular disease, metabolic syndrome, and type 2 diabetes as adults (Donovan, 2019).

Infant formula that contains whey protein-reduced whey or whey protein supplemented with α-lactalbumin or casein glycomacropeptide (CGMP) might further decrease the milk's protein level while enhancing its amino acid and nutritional makeup. Tinghall Nilsson et al. (2023) evaluated growth and protein metabolites.

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226 https://doi.org/10.54174/utjagr.v13ii_108

The ideal protein content in infant formulae is still up for debate. Compared to breast milk, which contains 9–11 g/L of protein, most infant formulas have a greater total protein concentration (13–15 g/L for cow's milk formulas and 18 g/L for soy formulas) in order to fulfil the amino acid needs of babies. Infant formulae, unlike breast milk, include a greater protein content, which may put metabolic stress on the growing infant's organs including the liver and kidneys (Tinghall Nilsson et al., 2024).

The disparities in newborn development between those who are breastfed and those who are given formula may be at least partially explained by this. The majority of the ingredients in infant formula now originate from cow's milk. Infants given formula have different growth and development outcomes compared to those breastfed because breast milk and cow's milk have different protein ratios, different amounts of certain proteins, and different amino acid profiles (Koletzko et al., 2009). This is because breast milk contains twice as many amino acids than cow's milk, including tryptophan and cysteine, which are much more abundant in breast milk. Additionally, compared to breast milk, the protein content of cow's milk is higher. Babies whose formulae include a greater protein content tend to acquire weight more rapidly compared to those who are breastfed.

(Koletzko et al.,2009 ; Krissansen,2007)

Table 2 Amino acid composition (Layman *et al*,2018)

"Amino acid	Milligrams of amino acid per gram of protein		
	α lactalbumin	**Whey**	Casein"
Histidine	30	22	25
Isoleucine	60	55	47
Leucine	108	122	89
Lysine	109	112	76
Methionine	10	23	26
Cysteine	48	30	3
Phenylalanine	41	36	51
Threonine	43	45	44
Tryptophan	48	27	12
Valine	43	52	59

Consuming a lot of protein while an infant is young causes them to put on weight quickly and store more fat. Blood concentrations of branched-chain amino acids (BCAAs) rise in response to elevated protein levels; this, in turn, raises insulin and insulin-like growth factor production.(Tinghall Nilsson *et al*.,2023 ; Kouwenhoven *et al*., 2021)

Oral tryptophan dosage influences CNS activities including behaviour, hunger, sleep, memory, learning, and neuronal development, among others. Reducing the total protein content while increasing the α-lactalbumin content in infant formula leads to an increase in the amino acid tryptophan (Table 1). According to clinical research, infant formulae with a lower protein content and a higher α-lactalbumin content may achieve the

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same elevated plasma concentrations of essential amino acids as babies nursed. (Nilsson *et al*., 2025)

Reducing the protein level in infant formula while raising the protein of α-lactalbumin and delivering the required amino acids, according to many studies, lowers the danger of excessive protein and promotes normal development .

(Sandström *et al*., 2008)

In (2004), Lien et al. conducted research that compared two different formulations, one with a moderate protein content and the other with a low protein content but enhanced with α-lactalbumin. During the course of two weeks, 134 newborns (those 14 days old or less) were the subjects of the research. The study indicated that there was no difference in growth rates or clinical indications between the two groups.

Babies whose formula contains tryptophan have better sleep, which may have an effect on their neurobehavioral development, according to the research. Babies can not grow and develop normally without enough sleep. Along with the hormone melatonin, tryptophan influences the brain chemical serotonin. (Trabulsi *et al*., 2011)

Researchers have shown that giving tryptophan to babies orally raises levels of serotonin and melatonin in their urine, and that giving tryptophan at night raises concentrations of these two neurotransmitters in their blood. (Aparicio *et al*., 2007)

Immunity and Gut Health

When it comes to the form and function of their cells, neonatal intestines are immature. To aid in the growth of the intestines, breast milk contains vital nutrients and physiologically active substances. The protective role of gut microbiotas against infections and pathogens is crucial. Compared to breastfed babies, those given formula had a more diversified and diversely composed gut flora (Davis et al., 2020).

The oligosaccharides found in breast milk, in contrast to cow's milk, encourage the development of good bacteria like Bifidobacterium. It is possible that breastfed and formula-fed newborns have different gut microbiota compositions..

(Brink *et al*., 2020 ; Davis *et al*., 2017)

Studies have indicated that bioactive peptides derived from α-lactalbumin promote a more favourable gut microbiome composition, closer to that of breastfed infants (Nielsen, 2020).

(Layman *et al*., 2018) confirmed the antimicrobial and antidiarrheal effects of α-lactalbumin -derived diets in infants fed a low-protein diet, in addition to the potential antiviral and immunomodulatory effects of α-lactalbumin peptides.

Clinical studies on infant formula fortified with α-lactalbumin protein have shown activity against Escherichia coli strains and reduced the incidence of diarrhea compared to breast milk (Lisak Jakopović *et al*., 2016).

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Digestion releases a number of proteins, including lactalbumin, lactoferrin, immunoglobulins, and lysozyme, along with the amino acids and peptides that link them. These proteins and their related roles impact microbial activity and digestion in several physiological ways. Intestinal tryptophan functions as a regulator, being a direct precursor of serotonin. Glutathione, an antioxidant and anti-inflammatory, has cysteine as its immediate precursor (Wu, 2013).

Breast milk helps the infant develop normally and also protects them against infections, particularly those that affect the digestive system, the lungs, and the ears (otitis media). Babies' immune systems rely on many bioactive components found in breast milk to develop and operate properly (Dib et al., 2024; Carr et al., 2021). What a newborn eats in the first few months of life greatly influences the composition of their gut microbiota and, by extension, how their immune system matures and works. (Davis *et al*., 2017). Dupont *et al*. (2010) compared two groups of colic-prone infants aged 3 weeks and 3 months. One group was fed high-protein milk (15 g/L) and the other a high- α-lactalbumin formula. While both groups experienced similar growth, the α-lactalbumin group experienced fewer feeding-related gastrointestinal adverse events. Lisak Jakopović *et al*. (2016) confirmed that lactalbumin inhibits intestinal pathogens E. coli, Salmonella, and Shigella. These tiny peptides may stop colon infections before they start by preventing germs from sticking to intestinal cells. Because of this, it is possible that infant formula with lactalbumin added may prevent E. coli and diarrhoea caused by other bacteria.

The immunomodulatory capabilities of α-lactalbumin-derived proteins, peptides, or enzyme hydrolysates have been the subject of several investigations. These studies have shown certain immunological activities, including lymphocyte activation and proliferation, cytokine release, and antibody formation. In vivo studies in mice have indicated that both native and hydrolyzed forms of α-lactalbumin enhance the immune response (Lisak Jakopović *et al*., 2016)

Nilsson *et al*. (2025) conducted a study on a group of infants aged 2 to 6 months fed formula containing 1.75 g of protein per 100 kcal. The first group (glycomacropeptide-1.76 g protein/100 kcal, 14% α-lac) and the second and third groups (glycomacropeptide-2.2 g protein/100 kcal, 10% α-lac) were used. Disease incidence and immunity were assessed. No effect on infection-related disease incidence or immune response was observed with increased α-lactalbumin concentration in breast milk compared to formula feeding. By introducing a modified low-protein formula to infants as early as six months of age, we may decrease insulin resistance and bring their growth, insulin levels, and C-peptide concentrations closer to those of breastfed infants at the same age. (Nilson *et al*., 2024)

Metal Absorption

For babies to develop quickly, it is important to provide them minerals like zinc and iron. Research has shown that α-lactalbumin protein improves calcium binding and zinc and iron absorption by increasing its bioavailability. The release of peptides during the digestion of α-lactalbumin protein is associated with a strong binding of iron, according to Layman et al. (2018).

More than that, alpha-lactalbumin encourages the development of good bacteria like Bifidobacteria, which lowers the pH in the intestines and might improve mineral absorption (Davis et al., 2017).

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Alpha-lactalbumin protein also contains a zinc-binding site, located in human α-lactalbumin between the amino acid's glutamic acid and glutamic acid. Calcium ions (Ca2+) can bind to this primary binding site. The most important characteristic of α-lactalbumin its ability to bind to metal ions. Therefore, the stability of the α-lactalbumin molecule (its tertiary structure) is directly affected by the calcium ion binding site. Permyakov *et al*., 2020).

The calcium binding site consists of oxygen bonds to the carboxyl group of three aspartic acid residues and one water molecule, lysine, and aspartic acid. (N`Negue *et al*., 2006)

Alpha-lactalbumin contributes to the presence of cysteine, oxidative stress, and immunity. The distinctive amino acid profile of whey proteins is responsible for their capacity to improve immunological function by increasing cysteine-based glutathione synthesis. This serves as the immune system's principal source of energy while also protecting cells from oxidative damage. Choi et al. (2015) found that glutathione has several functions in signal transduction, gene expression, and the elimination of reactive oxygen species.

α-lactalbumin possesses a single strong binding site for calcium (Ca2+) ions, which can also bind to manganese (Mn2+), magnesium (Mg2+), potassium (K+), sodium (Na+), and some other metal cations. It also contains multiple binding sites for zinc (Zn2+) ions. The physical properties of alpha-lactalbumin (α-LA) are highly dependent on the occupancy of its binding sites by metal ions (Permyakov *et al*., 2020).

Applications of α-lactalbumin in the treatment of cancer

Cancer remains one of the biggest threats facing humanity, and there is a huge demand for compounds capable of selectively killing cancer cells. Previous studies have shown that BAMLET (Bovine Alpha-Lactalbumin-modified cytotoxic protein) becomes toxic to cancer cells when bound to oleic acid (Yarramala *et al.*, 2019).

Researchers found that alpha-lactalbumin, when fed to mice with whey protein concentrates instead of casein concentrates, increased glutathione levels, improved immunity, and inhibited tumour growth. The study found that whey protein concentrates reduced the incidence of chemically induced colon tumours in mice (Permyakovet *et al*., 2020). In addition, Kent et al. (2003) reported that the animals that ate whey protein had reduced numbers of cancerous tumours compared to those that ate casein alone. Casein or soybean. Based on these results, whey protein could possibly protect the cells against ROS and cell death in epithelia, increase cellular glutathione levels, and increase tissue or active peptide glutathione levels.

Finding that milk protein extracts may be able to lessen the impact of the bacteria causing pneumonia to cling to respiratory epithelial cells, Ho et al. (2017) identified the HAMLET compound, a combination of lactalbumin protein and oleic acid. They found a protein-rich milk product which neutralized germs and cancer cells, and did not affect healthy cells.

The exact source of these chemicals (HAMLET/BAMLET) in milk or their formation in human digestion of dairy products remains unknown. Lisak Jakopović and colleagues (2016).Oleic acid protein complexes including alpha-lactalbumin are lethal to cells of many malignant and infectious diseases. α-Lacalbumin is responsible for transporting harmful fatty acid molecules across cell membranes to cancer and bacterial cells.

This mechanism could include α-LA complexes with oleic acid. Future anticancer medication development will make advantage of it. (Permyakov *et al*., 2020)

Biochemical studies shown that α-LA compounds containing linoleic acid also display substantial dose-dependent cytotoxicity against human lung cancer cells, in contrast to compounds including stearic acid, which did not demonstrate any cytotoxicity towards cancer cells. (Permyakov *et al*., 2020)

Yarramala *et al*.,(2019) studied the reaction of lanthanum trivalent ions (La3+) with α-lactalbumin protein to form complexes and induce structural changes. The reaction was studied using spectroscopy and thermometry. The protein structure was analyzed, and the complex exhibited selective anticancer activity against various cancer cell lines.

According to Uversky et al. (2017), camel-derived α-lactalbumin protein, both in its free form and as a compound with oleic acid, exhibited anticancer potential. Research using four different types of human cancer cells—MCF-7 breast cancer cells, HepG-2 liver cancer cells, Caco-2 colon cancer cells, and PC-3 prostate cancer cells—found that OA-α-cLA was a productive anticancer agent. The two functional components, α-cLA and OA, each have their own unique set of actions. This research points to OA-α-cLA as a potential anticancer drug with promising results.

Alpha- Lactalbumin: Adult Health

Supplements for adults often include whey proteins because of their nutritional content, water solubility, and appealing flavour, in addition to the fact that they are rich in important amino acids. Perhaps the most notable characteristic of these proteins is that they are an excellent source of leucine, a branched-chain amino acid (BCAA) that plays a unique role in stimulating muscle protein synthesis after meals. The high amounts of specific amino acids in whey protein isolate also allows for adequate muscle protein synthesis, besides reducing protein intake and calorie levels. Due to its properties it is a dietary supplement for athletes and for people who are susceptible to a decrease of skeletal muscle mass associated with ageing, bed rest, weight loss, or other factors. (Murphy et al., 2016)

Athletes and others who are susceptible to skeletal muscle loss due to ageing, bed rest, or weight reduction utilise it as a nutritional supplement because of these characteristics (Murphy et al., 2016). Adults often consume isolated whey proteins, but the greater difficulty of isolating lactalbumin proteins has meant that they have not garnered the same level of interest for usage in adult nutrition. Traditional methods. However, ultra-purified proteins are now a reality because to advancements in filtering and ion exchange techniques. Proteins, lipids, lactose, and other compounds are absent from α-lactalbumin in 93% of cases. In addition to its unique composition of amino acids and biologically active peptides (Table 2), the high tryptophan content of lactalbumin used in adult nutrition has neuromodulatory or behavioural effects, such as on sleep and mood (Layman *et al*., 2018).

Adults who take a supplement containing tryptophan report better sleep quality, with longer total sleep duration and less waking time. Classification of sleep disorders: insomnia and those that do not. Supplemental tryptophan also has the ability to regulate the phases of sleep. Taken one gram before bed, tryptophan levels have varied from very low to extremely high (Silber & Schmitt, 2010).

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Among the many cell types in the body that make melatonin, enterococcal cells in the intestines use tryptophan as their precursor. After serotonin undergoes its typical conversion to melatonin, it is N-acetylated and O-converted. Oral tryptophan increases blood melatonin levels via stimulating the production and release of melatonin by enteroendocrine cells (Trabulsi et al., 2011).

Melatonin is able to pass between the blood and brain easily since it is a fat-soluble hormone. Tryptophan may help with better sleep quality since it increases melatonin synthesis in the intestines, which is why melatonin enhances sleep. We still do not know if dietary proteins may enhance sleep quality, which is a big deal since sleep is so crucial. The possible effect of dietary tryptophan supplementation on these alterations will be the subject of future research. In addition to figuring out when to eat and how much protein to take, this will aid with sleep quality. (The year 2025, according to Nilsson and colleagues)

There are many studies that have dealt with the effect of tryptophan and mood, as tryptophan was given to patients with depression for several days or weeks alone and in conjunction with an antidepressant drug. Tryptophan has been found to have an antidepressant effect on its own. To enhance the effectiveness of monoamine oxidase inhibitors (MAOIs), chloropyramine, a tricyclic antidepressant, has been used. It moderately affects serotonin levels. In one study, an inactive dose of an MAOI combined with tryptophan resulted in a potent antidepressant effect. Studies of these combination therapies have suggested that serotonin functions. Its production will be enhanced by stimulating it through tryptophan supplementation.

Researchers Layman et al. (2018) found that in mice with a hereditary susceptibility to epilepsy, 5-hydroxytryptophan amplifies the anticonvulsant effects of the serotonin reuptake inhibitor fluoxetine. If tryptophan does, in fact, have an anticonvulsant effect, then these findings point to the need for a very large additional dosage. α-lactalbumin has a larger proportion of leucine compared to the proteins found in eggs, cattle, soy, and wheat, and it also has a higher concentration of branched-chain amino acids (BCAAs) such valine, isoleucine, and leucine. Leucine is considered a nutritional regulator for skeletal muscle growth through the activation of the leucine-derived signalling complex mTORC1, which plays a role in stimulating skeletal muscle protein synthesis after meals (Layman *et al*., 2015; Wolfe, 2017).

Evidence from Giesbertz and Daniel (2016) supports the idea that branched-chain amino acid (BCAA) breakdown produces muscle glutamate, and that long-distance runners may benefit from taking BCAA supplements to regulate their immune systems.

The unusual tryptophan content of α-lactalbumin makes it a potential dietary supplement for adults to aid with neurological function and sleep. Lactalbumin also contains bioactive peptides that have prebiotic and antimicrobial characteristics, as well as the branched-chain amino acid leucine, which enhances protein synthesis in skeletal muscle (Ponchon et al., 2024).

Conclusions

α-lactalbumin is the predominant protein in breast milk. To recent advancements, the availability of pure lactalbumin has opened new avenues for research into its applications in food and medicine. α-lactalbumin is a protein with excellent physical properties, including pure flavour, thermal stability, and high-water solubility. It also possesses high bioavailability, making it suitable for a variety of food applications.

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)

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There are two applications of α-lactalbumin: 1) as a supplement to improve mood or sleep; and 2) in infant formula that is designed to mimic breast milk. The elevated quantity of the vital amino acid tryptophan, a precursor to serotonin, is the source of its distinctive amino acid makeup, which gives it applications in cancer therapy and immune response enhancement. There are also peptides that could have biological activity, branched-chain amino acids and lysine. Therefore, α-lactalbumin may be a protein supplement which helps the babies' development and enhances their digestive and immune system systems. Proteins of the α-lactoglobulin type are also attracting a lot of interest for adult feed.

III. References

Aparicio, S., Garau, C., Esteban, S., Nicolau, M. C., Rivero, M., & Rial, R. V. (2007). Chrononutrition: use of dissociated day/night infant milk formulas to improve the development of the wake–sleep rhythms. Effects of tryptophan. *Nutritional neuroscience*, *10*(3-4), 137-143.

Brink, L. R., Mercer, K. E., Piccolo, B. D., Chintapalli, S. V., Elolimy, A., Bowlin, A. K., ... & Yeruva, L. (2020). Neonatal diet alters fecal microbiota and metabolome profiles at different ages in infants fed breast milk or formula. *The American journal of clinical nutrition*, *111*(6), 1190-1202.

Carr, L. E., Virmani, M. D., Rosa, F., Munblit, D., Matazel, K. S., Elolimy, A. A., & Yeruva, L. (2021). Role of human milk bioactives on infants' gut and immune health. *Frontiers in immunology*, *12*, 604080.

Choi, I. Y., Lee, P., Denney, D. R., Spaeth, K., Nast, O., Ptomey, L., ... & Sullivan, D. K. (2015). Dairy intake is associated with brain glutathione concentration in older and oxidant-induced cell death in human prostate epithelial cells.adults. *The American journal of clinical nutrition*, *101*(2), 287-293.

Cuevas-Gómez, A. P., Arroyo-Maya, I. J., & Hernández-Sánchez, H. (2021). Use of α-lactalbumin [α-La] from whey as a vehicle for bioactive compounds in food technology and pharmaceutics: A review. *Recent Progress in Materials*, *3*(2), 1-11.

D'Onofrio, N., Cacciola, N. A., Martino, E., Borrelli, F., Fiorino, F., Lombardi, A., ... & Campanile, G. (2020). ROS-mediated apoptotic cell death of human colon cancer LoVo cells by milk δ-valerobetaine. *Scientific Reports*, *10*(1), 8978.

Davis, E. C., Dinsmoor, A. M., Wang, M., & Donovan, S. M. (2020). Microbiome composition in pediatric populations from birth to adolescence: impact of diet and prebiotic and probiotic interventions. *Digestive diseases and sciences*, *65*(3), 706-722.

Davis, E. C., Wang, M., & Donovan, S. M. (2017). The role of early life nutrition in the establishment of gastrointestinal microbial composition and function. *Gut microbes*, *8*(2), 143-171.

Dib, S., Fair, F. J., McCann, L. J., Nicholls, A., Kalea, A. Z., Soltani, H., & Fewtrell, M. (2024). Effects of exclusive breastfeeding promotion interventions on child outcomes: a systematic review and meta-analysis. *Annals of Nutrition and Metabolism*, *80*(2), 57-73.

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)

https://iasj.rdd.edu.iq/journals/journal/issue/20226 https://doi.org/10.54174/utjagr.v13ii_108

Ding, X., Yang, Y., Zhao, S., Li, Y., & Wang, Z. (2011). Analysis of α-lactalbumin, β-lactoglobulin A and B in whey protein powder, colostrum, raw milk, and infant formula by CE and LC. *Dairy science & technology*, *91*(2), 213-225.

Donovan, S. M. (2019, March). Human milk proteins: composition and physiological significance. In *Nestle Nutr Inst Workshop Ser* (Vol. 90, pp. 93-101).

Dupont, C., Rivero, M., Grillon, C., Belaroussi, N., Kalindjian, A., & Marin, V. (2010). α-Lactalbumin-enriched and probiotic-supplemented infant formula in infants with colic: growth and gastrointestinal tolerance. *European journal of clinical nutrition*, *64*(7), 765-767.

Giesbertz, P., & Daniel, H. (2016). Branched-chain amino acids as biomarkers in diabetes. *Current Opinion in Clinical Nutrition & Metabolic Care*, *19*(1), 48-54.

Ho, J. C., Nadeem, A., & Svanborg, C. (2017). HAMLET–A protein-lipid complex with broad tumoricidal activity. *Biochemical and biophysical research communications*, *482*(3), 454-458.

Kamau, S. M., Cheison, S. C., Chen, W., Liu, X. M., & Lu, R. R. (2010). Alpha-lactalbumin: its production technologies and bioactive peptides. *Comprehensive Reviews in Food Science and Food Safety*, *9*(2), 197-212.

Katab, M. S., & Doosh, K. S. (2017). Isolation, Purification and Characterization lactoferrin from Whey protein and study some of its molecule characteristics. Al-Anbar Journal of Veterinary Sciences, 10(2), 62-71.

Koletzko B, von Kries R, Closa R, (2009). Lower protein in infant formula is associated

with lower weight up to age 2 y: a randomized clinical trial. Am J Clin Nutr. ;89:1836–1845

Kouwenhoven, S. M., Fleddermann, M., Finken, M. J., Twisk, J. W., van Der Beek, E. M., Abrahamse-Berkeveld, M., ... & Koletzko, B. V. (2021). Early-life metabolic and hormonal markers in blood and growth until age 2 years: results from a randomized controlled trial in healthy infants fed a modified low-protein infant formula. *Nutrients*, *13*(4), 1159.

Krissansen GW. (2007); Emerging health properties of whey proteins and their clinical implications. J Am Coll Nutr. 26:713S–723S

Krissansen, G. W. (2007). Emerging health properties of whey proteins and their clinical implications. *Journal of the American College of Nutrition*, *26*(6), 713S-723S.

Lajnaf, R., Picart-Palmade, L., Attia, H., Marchesseau, S., & Ayadi, M. A. (2017). Foaming and adsorption behavior of bovine and camel proteins mixed layers at the air/water interface. *Colloids and Surfaces B: Biointerfaces*, *151*, 287-294.

Layman, D. K., Anthony, T. G., Rasmussen, B. B., Adams, S. H., Lynch, C. J., Brinkworth, G. D., & Davis, T. A. (2015). Defining meal requirements for protein to optimize metabolic roles of amino acids. *The American journal of clinical nutrition*, *101*(6), 1330S-1338S.

Layman, D. K., Lönnerdal, B., & Fernstrom, J. D. (2018). Applications for α-lactalbumin in human nutrition. *Nutrition reviews*, *76*(6), 444-460.

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)

https://iasj.rdd.edu.iq/journals/journal/issue/20226 https://doi.org/10.54174/utjagr.v13ii_108

Layman, D. K., Lönnerdal, B., & Fernstrom, J. D. (2018). Applications for α-lactalbumin in human nutrition. *Nutrition reviews*, *76*(6), 444-460.

Lien EL.(2003)Infant formulas with increased concentrations of alpha-lactalbumin. Am

J Clin Nutr.;77:1555S–1558S.

Lien, E. L., Davis, A. M., Euler, A. R., & Multicenter Study Group. (2004). Growth and safety in term infants fed reduced-protein formula with added bovine alpha-lactalbumin. *Journal of pediatric gastroenterology and nutrition*, *38*(2), 170-176.

Lisak Jakopović, K., Barukčić, I., & Božanić, R. (2016). Physiological significance, structure and isolation of α-lactalbumin. *Mljekarstvo: časopis za unaprjeđenje proizvodnje i prerade mlijeka*, *66*(1), 3-11.

Lo¨nnerdal B, & Lien EL. (2003) Nutritional and physiologic significance of alphalactalbumin in infants. Nutr Rev.; 61:295–305.

Lönnerdal, B. (2014). Infant formula and infant nutrition: bioactive proteins of human milk and implications for composition of infant formulas. *The American journal of clinical nutrition*, *99*(3), 712S-717S.

Lönnerdal, B., Erdmann, P., Thakkar, S. K., Sauser, J., & Destaillats, F. (2017). Longitudinal evolution of true protein, amino acids and bioactive proteins in breast milk: a developmental perspective. *The Journal of nutritional biochemistry*, *41*, 1-11.

Murphy, C. H., Saddler, N. I., Devries, M. C., McGlory, C., Baker, S. K., & Phillips, S. M. (2016). Leucine supplementation enhances integrative myofibrillar protein synthesis in free-living older men consuming lower-and higher-protein diets: a parallel-group crossover study. *The American Journal of Clinical Nutrition*, *104*(6), 1594-1606.

N'Negue, M. A., Miclo, L., Girardet, J. M., Campagna, S., Mollé, D., & Gaillard, J. L. (2006). Proteolysis of bovine α-lactalbumin by thermolysin during thermal denaturation. *International Dairy Journal*, *16*(10), 1157-1167.

Nielsen, C. H., Hui, Y., Nguyen, D. N., Ahnfeldt, A. M., Burrin, D. G., Hartmann, B., ... & Bering, S. B. (2020). Alpha-lactalbumin enriches whey protein concentrates to improve gut, immunity and brain development in preterm pigs. *Nutrients*, *12*(1), 245.

Nilsson, U. T., Hernell, O., Lönnerdal, B., Jacobsen, L. N., Nunez-Salces, M., Kvistgaard, A. S., ... & Åkeson, P. K. (2025). Immunological effects of alpha-lactalbumin-enriched low-protein infant formula: A randomized controlled trial. *Journal of Pediatric Gastroenterology and Nutrition*, *81*(5), 1296-1305.

Permyakov EA, & Berliner LJ.(2000)a-Lactalbumin: structure and function. FEBS Lett. ; 473:269–274.

Permyakov, E. A. (2020). α-Lactalbumin, amazing calcium-binding protein. *Biomolecules*, *10*(9), 1210.

Ponchon, P., Goulding, D. A., Kennedy, E., Giuffrida, F., Ambühl, M., Morgenegg, C., ... & O'Regan, J. (2024). Application of a whey protein ingredient for simultaneous co-enrichment of infant

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)

https://iasj.rdd.edu.iq/journals/journal/issue/20226 https://doi.org/10.54174/utjagr.v13ii_108

formula with α-lactalbumin and milk fat globule membrane. *International Dairy Journal*, *152*, 105877.

Romano, A., Lajterer, C., Shpigelman, A., & Lesmes, U. (2021). Bovine alpha-lactalbumin assemblies with capsaicin: Formation, interactions, loading and physiochemical characterization. *Food chemistry*, *352*, 129306.

Sandström, O., Lönnerdal, B., Graverholt, G., & Hernell, O. (2008). Effects of α-lactalbumin–enriched formula containing different concentrations of glycomacropeptide on infant nutrition. *The American journal of clinical nutrition*, *87*(4), 921-928.

Silber, B. Y., & Schmitt, J. A. J. (2010). Effects of tryptophan loading on human cognition, mood, and sleep. *Neuroscience & biobehavioral reviews*, *34*(3), 387-407.

Tavares, T., del Mar Contreras, M., Amorim, M., Pintado, M., Recio, I., & Malcata, F. X. (2011). Novel whey-derived peptides with inhibitory effect against angiotensin-converting enzyme: In vitro effect and stability to gastrointestinal enzymes. *Peptides*, *32*(5), 1013-1019.

Tinghäll Nilsson, U., Hernell, O., Lönnerdal, B., Hartvigsen, M. L., Jacobsen, L. N., Kvistgaard, A. S., & Karlsland Åkeson, P. (2023). Low-protein formulas with alpha-lactalbumin-enriched or glycomacropeptide-reduced whey: Effects on growth, nutrient intake and protein metabolism during early infancy: A randomized, double-blinded controlled trial. *Nutrients*, *15*(4), 1010.

Tinghäll Nilsson, U., Hernell, O., Lönnerdal, B., Hartvigsen, M. L., Jacobsen, L. N., Kvistgaard, A. S., & Karlsland Åkeson, P. (2023). Low-protein formulas with alpha-lactalbumin-enriched or glycomacropeptide-reduced whey: Effects on growth, nutrient intake and protein metabolism during early infancy: A randomized, double-blinded controlled trial. *Nutrients*, *15*(4), 1010.

Tinghäll Nilsson, U., Lönnerdal, B., Hernell, O., Kvistgaard, A. S., Jacobsen, L. N., & Karlsland Åkeson, P. (2024). Low-protein infant formula enriched with alpha-lactalbumin during early infancy may reduce insulin resistance at 12 months: a follow-up of a randomized controlled trial. *Nutrients*, *16*(7), 1026.

Trabulsi, J., Capeding, R., Lebumfacil, J., Ramanujam, K., Feng, P., McSweeney, S., ... & DeRusso, P. (2011). Effect of an α-lactalbumin-enriched infant formula with lower protein on growth. *European journal of clinical nutrition*, *65*(2), 167-174.

Uversky, V. N., El-Fakharany, E. M., Abu-Serie, M. M., Almehdar, H. A., & Redwan, E. M. (2017). Divergent anticancer activity of free and formulated camel milk α-lactalbumin. Cancer Investigation, 35(9), 610-623.

Wolfe, R. R. (2017). Branched-chain amino acids and muscle protein synthesis in humans: myth or reality? *Journal of the International Society of Sports Nutrition*, *14*(1), 30.

Wu G. (2013)Synthesis of amino acids. In: Amino Acids: Biochemistry and Nutrition.

Boca Raton, FL: CRC Press, Taylor & Francis Group;:63–96

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)

https://iasj.rdd.edu.iq/journals/journal/issue/20226 *https://doi.org/10.54174/utjagr.v13ii_108*

Yarramala, D. S., Prakash, P., Ranade, D. S., Doshi, S., Kulkarni, P. P., Bhaumik, P., & Rao, C. P. (2019). Cytotoxicity of apo bovine α-lactalbumin complexed with La3+ on cancer cells supported by its high-resolution crystal structure. *Scientific Reports*, *9*(1), 1780.