International Journal of Chemical and Biochemical Sciences
(ISSN 2226-9614)

Journal Home page: www.iscientific.org/Journal.html

Camel Milk as a Promising Infant's Formula (IF) to Improve the Health and Nutritional Status of Infants and Young Children: A Systematic Review

Ruya Mohammed Alshebrami[1], Waheeba E. Ahmed [1,2], Mona S. Almujaydil[1]

1 Department of Food Science and Human Nutrition, College of Agriculture and Food Science, Qassim University, Buraidah 51452, Saudi Arabia.

2 Department of Food Science and Technology, College of Agriculture, Alzaiem Alazhari University, Khartoum, Sudan.

Abstract

Milk is an important food for children. Camel milk (CM) differs from other ruminant milk and is closest to human breast milk because it is rich in vitamin C, minerals, probiotics and protective proteins like lysozyme, immunoglobulins, lactoperoxidase, and lactoferrin and having low sugar and cholesterol. Because CM doesn't contain β-lactoglobulin, it is a substitute for people who can't tolerate the lactose in cow's milk. In terms of antioxidants, antimicrobials, anti-hepatitis, and anti-arthritis, Remedy for autoimmune illnesses. This systematic review is aimed at determining and reporting nutritional values and medicinal characteristics of camel milk in infants and young children, specially infants who are unable to breastfeed from their mothers. Methods: The search strategy of the current review is "(camel milk) and (autism, food allergy, milk allergy, children disease, young children, infants or formula infants." The search was conducted via PubMed, Scopus, and Google scholar. Also, Full-text papers on the topic of camel milk, evaluating nutritional value and medicinal properties which have been published from 2015 to 2024, were included in this systematic review. These findings revealed that camel milk is safer for children and has a unique nutritional value and medicinal properties, is effective in the treatment of autism, and improves general well-being. Also, the numerous nutrients in camel milk help to promote the body's natural defenses and thus can be considered as a good source of protein, calcium, phosphorus, vitamin C, and niacin and can meet part of the daily nutritional needs of humans. More large clinical trials are needed to support these findings. The researchers hope that these reports for pediatricians will lead to increased research on camel milk, its uses for young children and infants like formula and knowing its consequences and benefits.

Keywords: Camel milk, ASD, Autism, Infants, Young Children, Formula and Allergy.

Full length article **Corresponding Author*, e-mail: dt.roaya23@gmail.com, *Doi #* https://doi.org/10.62877/14-IJCBS-26-29-23-14
Submitted: 02-03-2026; Accepted: 07-04-2026; Published: 11-04-2026

1. Introduction

It is common knowledge that the best source of sustenance for an infant is their mother's milk. Due to the presence of bioactive components crucial for gut microbial colonization and immune maturation, human milk has been shown to have a multitude of protective factors against atopic disorders, reduce the risk of gastrointestinal and respiratory infections, and be compatible with an infant's digestive system. Breastfeeding, however, is not always possible. Follow-on formulas frequently end up being the only choice for feeding babies under six months old. Only 39% of babies under six months old are nursed exclusively globally, and only 15% of babies may be continuously breastfed for up to two years while also eating solid meals. Therefore, there is always a strong need to provide right substitutes for the mother's milk under certain circumstances [1]. Bovine milk is frequently used to make infant formula; however, it also includes β-Lactoglobulin (β-LG), the primary protein that causes allergies in babies. One advantage of camel milk is that it does not have β-LG, which might make it a practical alternative to bovine milk for preventing baby allergies and, so, suitable source for creation of infant milk formula (IMF).

Camel milk contains immunoglobulins that are comparable to those in human breast milk, which helps to boost children's immune systems and lessen allergic responses [2]. Additionally, camel whey has a high concentration of antimicrobial components [3]. Camel milk differs from other animals' milk and resembles human milk because it contains less κ-casein and no β-lactoglobulin. It is therefore a viable choice for people with a cow's milk protein allergy. Additionally, camel milk has low fat and lactose content and is high in vital elements including potassium,

iron, and vitamin C. Camels are a great source of natural antioxidants because, during gastrointestinal digestion, their milk proteins release special bioactive peptides. Particularly, camel whey protein is known to improve immune system performance, reduce oxidative stress, and raise glutathione levels. Lactoferrin, lactalbumin, lactoglobulins, lactoperoxidase, lysozyme, and immunoglobulins are all abundant in it [1]. This systematic review is aimed at finding and reporting nutritional values and medicinal characteristics of camel milk in infants and young children, specially infants who are unable to breastfeed from their mothers.

2. Methods

The search strategy of the current review is “camel milk) and (," The search was conducted via PubMed and Google scholar. Also, Full-text papers on the topic of camel milk, evaluating nutritional value and medicinal properties which have been published from 2015 to 2024, were included in this systematic review.

3. Results

1. Characterization and bioactive properties of camel and cow milk infant formulas

Characterization and bioactive properties of camel and cow milk infant formulas are shown in figure 1. From the figure 1, we can know that camel milk is higher in degree of hydrolysis, antioixidan activity, and anti-inflammatory activity compared to cow’s milk, making it best alternative to breast milk in cases where breastfeeding is not possible.

2. Protein and Peptide Profile and Digestion of Human, Cow and Camel Milk

Protein and peptide profile of human, cow and camel milk was shown in figure 2. The range of protein sequence identity between camel and cow's milk proteins was found to be between 47% and 81%. This is quite comparable to the range of 33% to 76% for the protein sequence identity of human and cow's milk proteins and 40% to 76% for those of human and camel milk proteins [2]. Furthermore, BLG is not present in human or camel milk. The primary proteins in both camel and cow milk were caseins, with β-casein being the most prevalent kind; nevertheless, the micelles of camel milk's casein are bigger than those of cow's milk. While κ-casein was more prevalent in cow's milk (60%), β-casein was more prevalent in camel milk (67%). The most prevalent whey protein in cow's milk was β-LG, which was not present in camel milk. Glycosylation-dependent cell adhesion molecule-1 (GLYCAM-1) and α-lactalbumin (α-LA) were the primary whey proteins found in camel milk [4-6].

3. Camel milk fat profile compares with that of cow and human milk

Figure 3 explained Camel milk fat profile compared with that of cow and human milk. While camel milk contained the highest monounsaturated fatty acid and poly unsaturated fatty acid contents like palmitoleic acid (4.8%) and olieic acid (30.2%), saturated fatty acids more prevalent in cow milk (67.2%) compered to cow’s and human milk [7-8]. The primary Essential amino acids in both camel and cow milk Leucine 5.98% and 8.89%, respectively, with iso leucine being the most prevalent kind [7]. In one other hand, human milk and camel milk were thoroughly examined. The findings indicated that the amounts of saturated fatty acids in camel milk and human milk are same. Polyunsaturated fatty acids were more prevalent in human milk, whereas monounsaturated fatty acids were more prevalent in camel milk. Human and camel milk were found to contain 146 and 136 triacylglycerols, respectively, using UPC2/Q-TOF-MS. Human milk has higher levels of triglycerides made of polyunsaturated fatty acids than camel milk. Five main phospholipid kinds were found in both human and camel milk; the total phospholipid concentration of camel milk was higher than that of human milk. Furthermore, camel milk has higher levels of fat-soluble vitamins and cholesterol (4%) compared to human milk (3%) [9].

4. Camel and Cow’s Milk Immunogenicity and Cross-Reactivity

According to one study, the immunogenicity and sensitizing potential of cow's and camel's milk can be decreased by hydrolyzing the enzymes. The immunogenicity and sensitizing potential of cow's milk, but not camel milk, may be diminished by extensive heat treatment. Enzyme hydrolysis seems to have a greater impact on cross-reactivity than heat treatment. The majority of infants with cow's milk allergies are expected to tolerate camel milk-based infant formula, and it is possible that partially hydrolyzed camel milk may even lower risk of allergic reactions, making it more tolerable for these infants. It may not advise utilizing camel milk in newborn formula since it appears that extensive heat treatment of milk does not lessen its immunogenicity, sensitizing potential, or cross-reactivity [6-7].

5. Hemoglobin level in children consuming camel milk and cow milk

Milk is a concentrated supply of macro- and micronutrients that are essential for supporting children's cognitive and physical development. It lowers child mortality and morbidity as well. But drinking cow's milk can put babies and toddlers at risk for low hemoglobin levels and iron storage depletion. Anemia and iron insufficiency have been linked to cow milk consumption through a number of methods. Among the most significant mechanisms are the naturally low iron content of cow's milk, the induction of intestinal bleeding in babies, and the anti-iron absorption impact of calcium and casein in non-heme cow's milk. In another hand, compared to cow milk (figure 4), camel milk has a higher iron content (1.35–2.5 mg/L vs. 0.3–0.8 mg/L). Furthermore, the majority of iron is linked to the smaller molecular fraction of casein, indicating improved bioavailability to boost hemoglobin synthesis and iron stores. Additionally, camel milk has a concentration of vitamin C that is more than three times higher than that of cow milk. By converting ferric iron into the easily accessible form of ferrous iron, vitamin C, whether it be naturally occurring in food or supplied from outside sources, improves iron absorption from non-heme sources. Because milk contains a lot of calcium and proteins, vitamin C can also counteract the effect of inhibiting iron absorption. These traits would suggest that camel milk consumption may benefit consumers more than cow milk in terms of improved hemoglobin production. According to a previous study, children who consumed camel milk had a considerably higher mean hemoglobin content (9.6±1.8g/dl) than children who consumed cow milk (9.1±2.2g/dl).

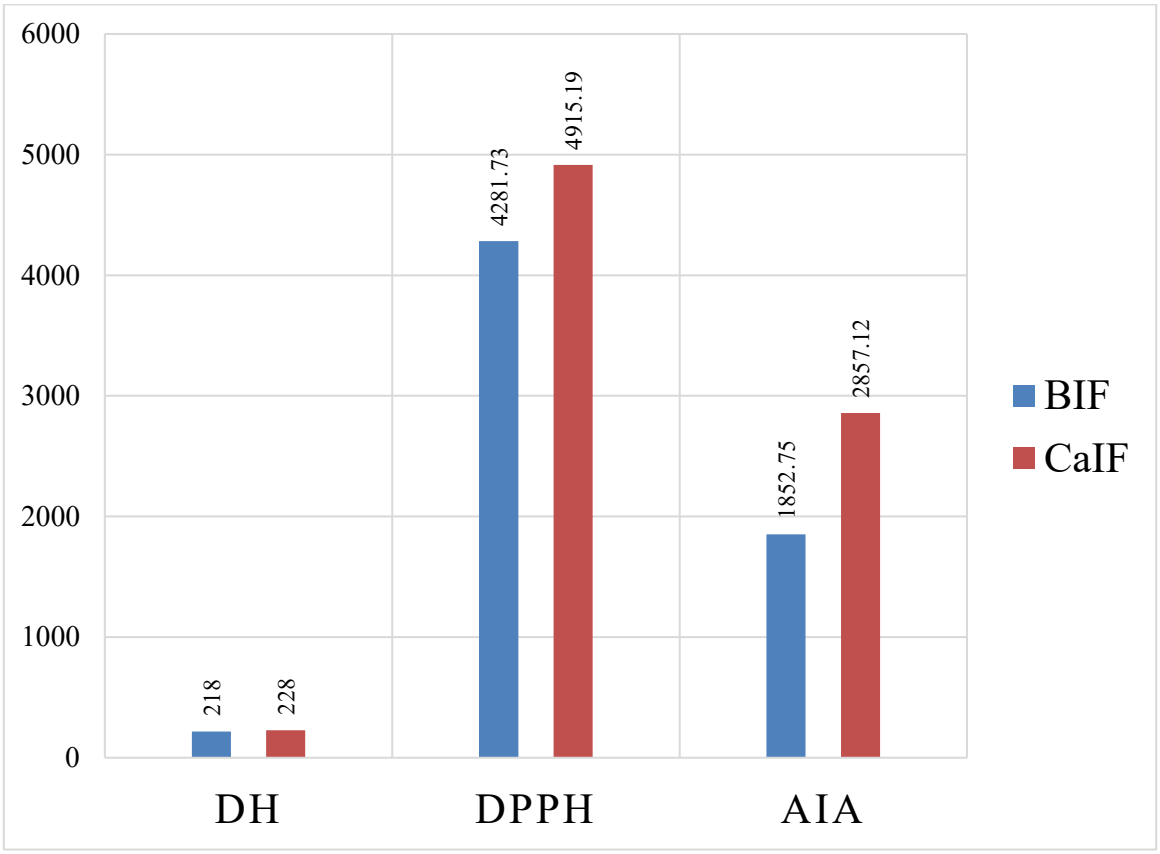

Figure 1. Characterization And Bioactive Properties Of Camel And Cow Milk Infants Formulas (BIF: bovine milk infant formula, CaIF: camel milk infant formula, DH: degree of hydrolysis (µg NH3 g^{-1}), DPPH: antioixidan activity (TEAC µM), AIA: anti-infalammatory activity (TEAC µM) [11].

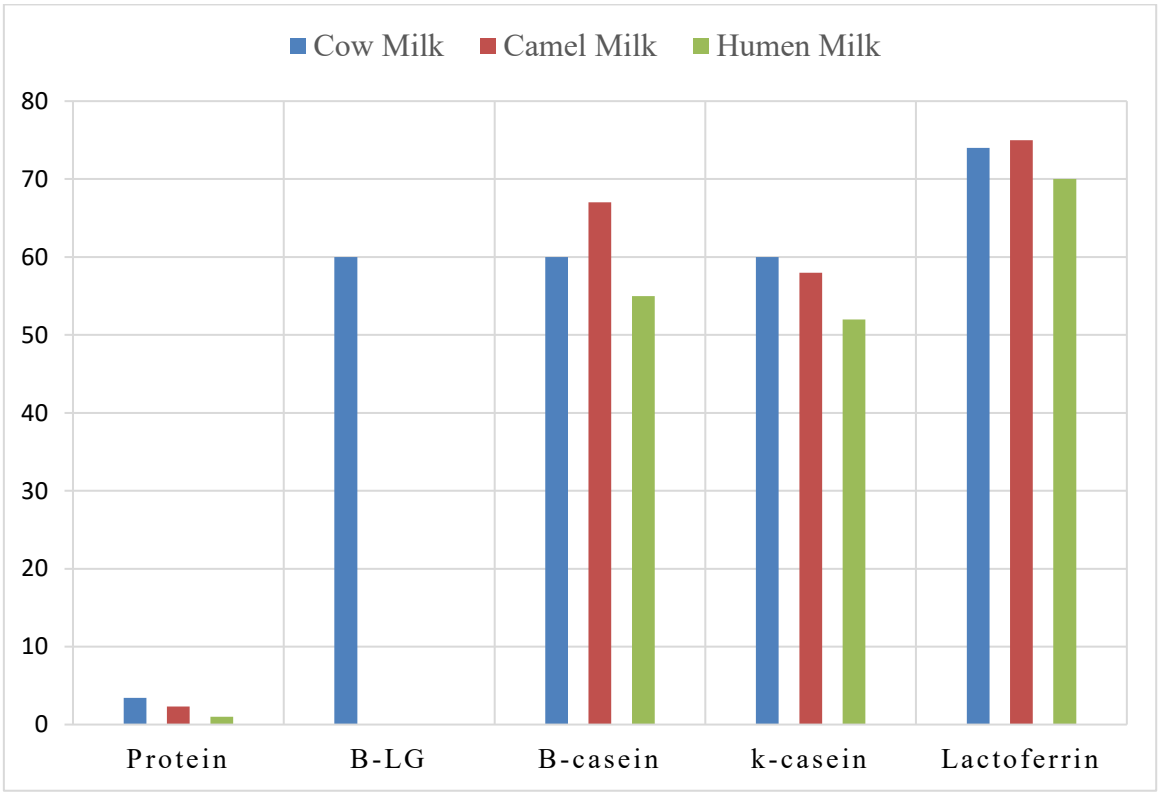

Figure 2. Protein and Peptide Profile of Human, Cow and Camel Milk (Protein [2], B-LG: B-lactoglobulin, b-casen, k-casen and lactoferrin (%) [4-6].

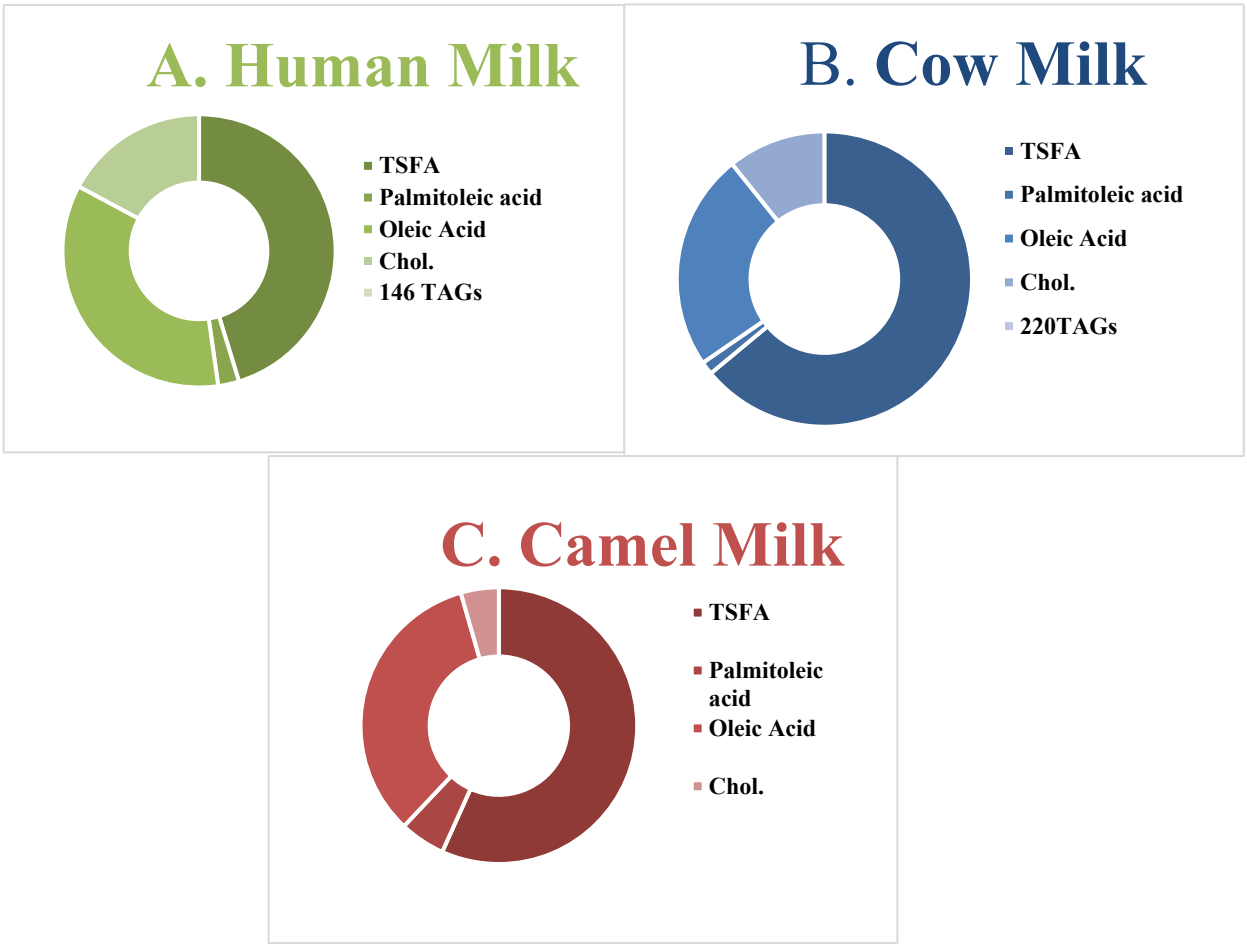

Figure 3. Camel milk fat profile compares with that of cow and human milk (TSFA: total saturated fatty acid, Palmitoleic acid and oleic acid [7-8], chol.: cholesterol [7] TAGs: Triglycerols [7-9].

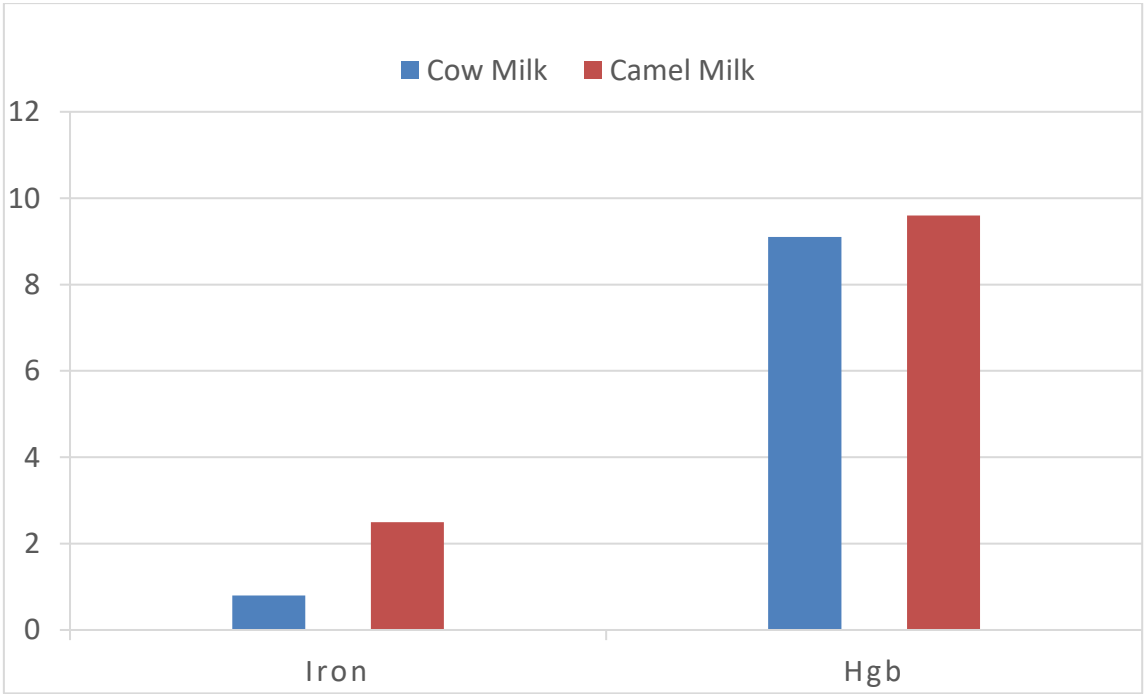

Figure 4. Hemoglobin level in children consuming camel milk and cow milk (Iron and Hgb: hemoglobin. Source: [10]

Nonetheless, children who drank cow or camel milk had comparable overall rates of anemia. This may imply that drinking camel milk instead of cow's milk improves hemoglobin concentrations, but it may not be enough to guarantee normal hemoglobin concentrations because of other contributing factors especially in populations from resource poor settings[10].

6. Camel Milk and Autism Spectrum Disorder

Many studies have shown that camel milk is a promising treatment for autism due to its unique components that can reduce oxidative stress in autism patients, but it is recommended to conduct more studies using more advanced and accurate tools and on a larger scale [12].

7. Conclusions

The review concludes that camel milk can be a potential alternative milk source for infant formula. Camel milk showed a good source of antioxidant activity, and anti-inflammatory activity. Also, β -lactoglobulin was not present in camel milk this makes camel milk suitable for infant with lactose intolerance, but this recommendation needs further research to confirm. Furthermore, in the future we need to study the effect of camel milk in autism spectrum disorder due to its unique components like fatty acid, peptide, calcium, phosphorus, vitamin C, and niacin and can meet part of the daily nutritional needs of humans and reduce oxidative stress in autism patients.

References

[1] N.S. Al-Nassir, S.S. Sakr. (2024). In Vitro Digestibility Assessment of Whey from Goat and Camel Milk Fermented with Lactobacillus helveticus for Use as a Base in Formulating Follow-On Formula. Foods. 13(4): 570.

[2] M. Algaithi, P. Mudgil, M. Hamdi, A.A. Redha, T. Ramachandran, F. Hamed, S. Maqsood. (2022). Lactobacillus reuteri-fortified camel milk infant formula: Effects of encapsulation, in vitro digestion, and storage conditions on probiotic cell viability and physicochemical characteristics of infant formula. Journal of dairy science. 105(11): 8621-8637.

[3] M.M. Desouky, H.H. Salama. (2021). Preparation and properties of children food after weaning using camels' milk and guadar cereal nanoparticles. Journal of Food Processing and Preservation. 45(1): e15012.

[4] A. Runthala, M. Mbye, M. Ayyash, Y. Xu, A. Kamal-Eldin. (2023). Caseins: versatility of their micellar organization in relation to the functional and nutritional properties of milk. Molecules. 28(5): 2023.

[5] N.Z. Maryniak, M. Mancino, T.K.S. Sztuk, Y. Gao, A.I. Sancho, E.B. Hansen, K.L. Bøgh. (2024). Impact of processing on the sensitising capacity and cross-reactivity of cow's and camel milk proteins in a Brown Norway rat study. Food and Chemical Toxicology. 189: 114761.

[6] N.Z. Maryniak, A.I. Sancho, S.D. Nielsen, L.B. Larsen, Y. Gao, K.L. Bøgh, E.B. Hansen. (2024). Enzymatic hydrolysis and extensive heat treatment induce distinct modifications of cow's and camel milk proteins of relevance for production of infant formula. LWT. 191: 115591.

[7] M. Amr, A. Farid. (2024). Impact of cow, buffalo, goat or camel milk consumption on oxidative stress, inflammation and immune response post weaning time. Scientific reports. 14(1): 9967.

[8] Z. Zhang, Y. Wang, X. Yang, Y. Cheng, H. Zhang, X. Xu, J. Zhou, H. Chen, M. Su, Y. Yang. (2022). Human milk lipid profiles around the world: a systematic review and meta-analysis. Advances in Nutrition. 13(6): 2519-2536.

[9] I.A. Bakry, W. Wei, M.A. Farag, S.A. Korma, I. Khalifa, N.I. Ziedan, H.K. Mahdi, J. Jin, X. Wang. (2023). How does camel milk fat profile compare with that of human milk fat to serve as a substitute for human milk? International Dairy Journal. 146: 105738.

[10] A. Abdurahman, D. Gashu. (2021). Level of hemoglobin among cow milk and camel milk consuming young children: A comparative study. PLoS One. 16(3): e0247572.

[11] P. Mudgil, W.N. Baba, M. Alneyadi, A.A. Redha, S. Maqsood. (2022). Production, characterization, and bioactivity of novel camel milk-based infant formula in comparison to bovine and commercial sources. LWT. 154: 112813.

[12] L.Y. Al-Ayadhi, D.M. Halepoto, A.M. Al-Dress, Y. Mitwali, R. Zainah. (2015). Behavioral benefits of camel milk in subjects with autism spectrum disorder. J Coll Physicians Surg Pak. 25(11): 819-823.