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Characterization and Healthier Properties of Whey proteins of Camel Milk: A Review

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Abstract

Whey proteins from Camels' milk are characterized with different properties than cow whey proteins, and it is a chief source for milk in the desert areas. The co-precipitates proteins of camels' milk using different methods heat treatment with or without expansion of hydrochloric or calcium chloride corrosive just as precipitation after the convergence of proteins by ultra-filtration and afterward ponder its physical and utilitarian attributes to suggest use in the food industry**.** Camel milk proteins has bioactive parts of useful sustenances to open new market open doors as it is settled that diverse functional properties can be guaranteed by fusing milk proteins into different nourishments. A few examinations on camel milk proteins with respect to denaturation of whey proteins, development of protein films, froths, emulsions and milk gels have been led under explicit conditions.

Keywords: Camel milk, Whey proteins, Functional characteristics, bioactive components

1. Introduction

Whey is a protein rich by-product from cheese making (80%) and casein production, and a large proportion of the 90 billion lb. of the whey generated every year by the cheese industry in the US [34] is disposed to the environment. As the production of cheese worldwide continues to increase the levels of whey production (every ton of hard cheese producing 9 ton of whey) must also increase. Whey proteins represent 20% of total milk proteins [7] and so it is important that they be reused, not sent to waste.

Camel milk is extraordinary as far as dietary and remedial properties [29], too camel milk was accounted for to have hostile to diabetic properties. A few studies [10] found out that consumption of camel milk occasionally helped to control diabetes and reduced the daily insulin dosage needed for diabetic patients. Different investigations accentuated a hypoglycemic impact of camel milk on diabetic exploratory creatures [30].

Every detailed data [16] demonstrate that camel milk is by all accounts like dairy animals milk and not to human milk. Casein contentw of camel and dairy human milk is very comparable; in any case, the whey protein portion is higher in camel milk,

The ratio of whey protein to casein in camel milk is higher than in cow but lower than in human milk proteins. This may explain why the coagulum of camel milk is softer than that of cow milk [11]. In amino acid composition, several differences exist between human and cow milk, which can present problems in feeding cow milk - based formulae to convinced infants. Human milk has a high cystine : methionine ratio and some taurine [40]. Cow milk has a lower cystine : methionine ratio and essentially no taurine. The human infant's liver and brain have only low levels of cystathionase, the enzyme that converts methionine to cystine (the fetus and preterm infant are completely lacking this enzyme).

Cysteine is important for central nervous system development [40]. Taurine is made of cystine and is needed for brain and retinal development and function, and the conjugation of bile salts [25].

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The ratio of cystine: methionine is lower in camel milk (0.38) than in cow (0.5) and human (0.6) milk due to the high content of methionine in camel milk proteins.

Milk contains factors that have anticariogenic properties such as antibodies (immunoglobulins) and non - antibody components, i.e., complements, Lactoferrin, lactoperoxidase, lysozyme, xanthine oxidase, and leukocytes.

Camel milk is characterized by higher contents of immunoglobulins, lysozyme, and Lactoferrin [18]. In addition to these protective proteins, milk contains caseins, α - lactalbumin (α - La), β - lactoglobulin (β - Lg) and proteose - peptone fractions (heat - stable, acid – soluble phosphoglycoproteins), serum albumin, and other minor peptides. In addition to native protective proteins, other bioactive peptides may be generated from milk proteins through gastrointestinal digestion or during processing via specific enzyme - mediated proteolysis. The resulting active peptides are of particular interest in food science and nutrition because they have been shown to play physiological roles, including opioidlike features, immunostimulating and antihypertensive activities, and the capacity to upgrade calcium absorption.

2. Camel milk protein structure and function

Camel milk lacks β-Lg and is richer in α-La and serum albumin than bovine milk [17]. The bioactivities and functional properties of camel milk whey proteins can be further enhanced via generation of shorter bioactive peptides through enzymatic hydrolysis [32].

2.1. β-Lg & α-La

El-Hatmi *et.al.(2015)* [21] studied the qualitative whey proteins profile of camel milk. Whey proteins were fundamentally the same as that of human milk. Camel and human milk were found to have high substance of α-La and LF and to be without β-Lg, while it was the real whey protein part distinguished in test of cow and goat milk.

Further, thus camel milk was suggested to be the most suitable substitute for cow milk when considering preparation of infant formulas.

Henceforth, future examinations should concentrate on cleansing of single camel whey protein divisions so as to assess their immunoreactivity.

Ask et al. (1985) decided the essential structure of camel α - La by examination of the flawless protein, and of CNBr pieces and enzymatic peptides from the carboxymethylated protein chain. Results showed that camel α - La has 123 residues and a molecular mass of 14.6 kDa. Kappeler *et al.* (2003) [28] reported that the concentration of α - La in camel milk (3.5 g/L) is hither to that of human milk (3.4 g/L), compared with bovine milk (1.26 g/L). El - Hatmi *et al.* (2007) [20] recently reported that serum albumin is the major whey protein present in camel milk with an average concentration of 10.8 g/L.

Camel α-La, as bovine α-La, has a length of 123 amino acids, but with 39 positional differences. The MW is 14·4 kDa and the isoelectric point at pH 5·01. The protein seems not to be modified after translation. Differential cleavage of the signal peptide by three amino acids may result in an N-terminally shortened variant that is less abundant, has an MW of 14·0 kDa, and an isoelectric point at pH 4·87 [5].

Recently, acid whey prepared from camel milk was separated by HPLC analysis. Three peaks were identified by N - terminal sequencing as whey acidic protein, α - La and lactopherrin [26]. Their ratios were 86.6, 11.5, and 1.9% for α - La, lactopherrin, and whey acidic protein, respectively. SDS - PAGE of fractionated proteins showed that BSA and other proteins coeluted with α – La as minor fractions.

2.2. Lactopherrin

Camel milk lactopherrin is a major protein in whey, whereas bovine lactopherrin is a minor protein in whey. Camel LF has 689 amino acids residues, a MW of 75·3 kDa and an isoelectric point at pH 8·63 [27]. Camel LF is the first protein from the transferrin superfamily that has been found to display the two characteristic functions of iron scavenging (lactoferrin) and iron release (transferrin) simultaneously. This is because the N-lobe releases iron at a pH below 4·0 and the C-lobe releases iron at about pH 6·5.

Whereas the Nlobe exerts mainly an antimicrobial activity, the C-lobe contains five highly variable sequences that differ between species and have a demonstrated affinity for hepatitis C virus in the case of the camel variant.

The heat stability of the camel orthologue is similar to that of other species and the antimicrobial activity against the Gram-negative bacterium E. coli is higher than for other orthologues, including the human LF [23]. The common property of this protein family is the binding of two metalcations, preferably (Fe^{+3}), at structurally closely related biRnding sites. Most Lactoferrins are needed for storage or transport of iron. Lactoferrin was discussed to serve for iron scavenging in body secretions. It is found in milk, different other body secretions, and neutrophil leukocytes.

The control effect of Lactoferrin depends mainly on iron requirements of microorganisms. For example, *E. coli* is much more sensitive than lactic acid bacteria [36]. The inhibition effect of camel and bovine milk Lactoferrins against some strains of bacteria was studied by [12]. Both types of Lactoferrins were effective against Salmonella typhimurium , and the clearance inhibition zones were 18.2 and 17.4 mm for camel and bovine milk Lactoferrins, respectively. Neither camel nor bovine milk Lactoferrin had a lysis effect toward *E. coli* and *Staphylococcus aureus*.

Taking into account that the inhibition rate of camel Lactoferrin against such microorganisms was detected in synthetic media, this effect is probably different when liquid media such as milk are used, because it was reported that citrate ions can counteract the bacteriostatic activity of Lactoferrin, i.e., compete for iron, unless the bicarbonate concentration is high [36]. Therefore, it can be expected that Lactoferrin activity in camel milk will be higher due to the lower concentration of citrate ions [11]. It can be assumed that the inhibition effect of Lactoferrin in camel milk, when ingested by the nomads in the desert, is due to two main factors: 1) the low content of citrate in camel milk and 2) the high bicarbonate concentration in the intestinal fluid, where bicarbonate is the main buffer [36]. These two factors will provide the proper conditions for Lactoferrin to bind iron and inhibit sensitive microorganisms such as *E. coli*.

The concentration of lactopherrin in camel milk was found to be about 3 times higher than the concentration of the bovine homologue in bovine milk. This could be of higher potential benefit in milk processing, since lactophorrin is an inhibitor of lipase. It was accounted for that whey acidic protein, by and large depicted as a noteworthy constituent of rat milk, and peptidoglycan acknowledgment protein, an intracellular protein authoritative to Gram - positive microscopic organisms and by and by not known to be a milk constituent, were identified in significant sums in camel whey, both on the cDNA and protein level [28].

2.3. Immunoglobulins

Camel whey further contains IgG2 and IgG3, two immunoglobulin variants of an additional type not present in bovine milk [1,13,19,20]. These variants may provide camel milk with additional functionalities. particles to fuse and form larger aggregates [23].

The immunoglobulin molecule is composed of four polypeptide chains, two light chains (lambda or kappa) and two heavy chains (alpha, gamma, mu, and delta or epsilon). The type of heavy chain determines the immunoglobulin isotype, IgA (alpha), IgG (gamma), IgM (mu), IgD (delta), and IgE (epsilon). Immunoglobulin classes differ in amino acid composition and sequence as well as molecular weight. IgA is dominant in blood serum, and secretory IgA (sIgA) is dominant in milk. Three classes as IgG, IgA, and IgM are recognized in camel milk [12]. IgG class is found to have three different subclasses: IgG 1 , IgG 2 and IgG 3 . The molecular weights of heavy and light chains of camel immunoglobulins. Camel immunoglobulins have molecular weights different from those of cow, sheep, goat, mare, buffalo, and human [16]. The reactivity of camel blood serum or milk IgG to Protein A [12,24] or Protein G [24] was recognized. Secretory IgA and IgM have no affinity to protein A [24].

Total immunoglobulins in camel colostrum were determined by SDS - PAGE followed by densitometric analysis as 2.52% and 1.88% of total protein after 2 hours and 24 hours postparturition, respectively [43].

In another study [20], the concentration of total IgG in camel colostrum was 101.8 g/L and declined to 47.2 g/L after 24 hours of parturition. IgG 1 concentration represented 42.6% of total IgG in the same samples. IgG was estimated in camel milk from Kazakhstan, where two species of camels *Camelus bactrianus*, *Camelus dromedarius* and their hybrids cohabit. The concentration of IgG was determined according to three variation factors: region, season, and species. The mean values for IgG in raw camel milk was 0.718 ± 0.330 mg/mL.

The seasonal effect was the only significant variation factor observed, with the highest values in the winter for IgG. The IgG concentration varied from 132 to 4.75 mg/mL through the first week after parturition [31].

2.4. Lactoperoxidase

Lactoperoxidase is found in milk, tears, and saliva. It contributes to the nonimmune host defense system, exerting bactericidal activity mainly on Gram - negative bacteria. It is supposed that the main function in milk is the protection of the udder from microbial [42] Lactoperoxidase is resistant to proteolytic digestion and acidic pH. Lactoperoxidase activity is residual at a high level throughout lactation; however, human lactoperoxidase is present only in colostrum and becomes undetectable within one week after parturition) [42]. Lactoperoxidase was first isolated, crystallized, and characterized by Theorell and Akesson (1943) [41].

The lactoperoxidase (LP) mode of action is highly conserved between species and a high sequence identity of about 85% is reported between the respective human, camel and ruminant variations. Camel LP has 611 amino acids after evacuation of sign and propeptide; the unmodified chain has a MW of 69•3 kDa and an isoelectric point at pH 8•50 [26]. It applies an apparently high action in crude milk. The protein is much more warmth labile than the ruminant variations and action is beneath breaking point of recognition after sanitization. It might in this manner be utilized for protection of crude camel milk in the field in mix with thiocyanate and hydrogen peroxide, and as an indicator forpasteurization [23].

2.5. Lysozyme

The molecular mass of camel lysozyme was estimated at 14.4 kDa [15, 19] and 15 kDa [9] versus 15 kDa for either human or goat lysozyme. Immunological study [19] on camel milk lysozyme showed that there are no antigenic similarities between camel and bovine milk lysozyme, suggesting different structures.

Lysozyme C has been measured in scarce amounts in both camel and bovine milk, and is reported to have a similar MW of 14·4 KDa [19]. The enzyme is not, however, expressed in the healthy lactating mammary gland and was not found in mastitis-free milk [28]. The traces reported in camel milk are probably transferred from the blood serum.

A comparative study [18] of lysozyme concentration in milk of different species showed that camel milk had a considerably higher concentration of lysozyme than cow, sheep, buffalo and goat milk. However, lysozyme in camel milk was lower than those in human, donkey, and mare milk. The proportional convergence of lysozyme in camel milk was 11, 18, 10, and multiple times that of dairy animals, wild ox, sheep, and goat milk, respectively. Lysozyme concentration in milk varies according to some factors such as lactation period and health status of the animal. It increases in precolostrum, colostrum, and udder infection [8]. Camel colostrum contained higher convergences of lysozyme than normal milk.

The concentrations of lysozyme in camel milk were found to decrease rapidly within the first months of lactation [4]. Only one study has been carried out on the effect of heat treatment on protective proteins as immunoglobulins (IgGS), lysozyme, and lactoferrin [14]. In this study cow, camel and buffalo skim milk samples were heated at 65, 75, 85, and 100 ° C for 30 minutes. The results demonstrated that warming of the three sorts of milk at 65° C for 30 minutes had no significant effect on Lactoferrins and Lysozymes; however, a significant loss in IgG S activity was detected. The whole activity of IgG in both buffalo and cow milk was lost at 75 ° C for 30 minutes versus 68.7% in loss activity of camel IgG.

Among the protective proteins, the order of heat resistance found was lysozyme > Lactoferrin > IgG S .

The MWs of camel and bovine SA are 69·6, and 66 kDa, respectively [19]. A considerably higher concentration of SA has been reported for camel milk, as compared to bovine and human milk. Two whey protein components i.e. GlyCAM-1 and PGRPS, are found in a higher concentration in camel milk than in bovine milk [20].

The PGRP-S is a protective, antibiotic protein that is secreted from white blood cells and has the ability to depolarise bacterial membranes. It is bactericidal against both Gram-positive and Gram-negative bacteria, by inducing oxidative, thiol, and metal stress [23]. PGRP-S has been found in non-mastitic camel milk, but not in non-mastitic human or ruminant milk. The protein has 172 amino acids and an isoelectric point at pH 9·02. Its concentration decreased in the course of lactation by 19% and increased in the event of severe mastitis by 45% [28].

Two whey protein components i.e. GlyCAM-1 and PGRPS, are found in a higher concentration in camel milk than in bovine milk [20]. Camel whey further contains IgG2 and IgG3, two immunoglobulin variants of an additional type not present in bovine milk [1,19, 20]. These variants may provide camel milk with additional functionalities. Abderrahmane *et al.* (2015) [2].

3. Functional properties and applications of whey proteins of camel milk

The absence of β-Lg might explain some of the differences observed between camel and cow milk regarding technological properties such as thermal stability during drying, heat induced aggregation and adherence to heating surfaces (fouling properties) as well as the thin consistency found in fermented camel milk.

The higher abundance of α-La in camel milk whey resulted in greater sensitivity of camel whey solubility upon pH change, and in bovine milk this is known to cause acid denaturation. Bovine α-La will form aggregates in acidic medium unlike β-Lg; which will form aggregates upon heating in both alkaline and acidic mediums.

Camel SA is less heat sensitive than SA from bovine or buffalo milk and denaturation of camel SA at 100 °C for 20 min has been shown to be comparable to bovine and buffalo SA heated at 85 °C for 20 min [14]. However, the fouling properties (adherence of milk proteins to heated surfaces) of camel milk has been attributed mainly to α-La and SA whereas β-Lg is the main foulant in cow milk [22].

Functional properties of whey protein products are affected by the technological processing (i.e. heat treatment) implemented during the manufacturing process. The effect of temperature on solubility of camel and bovine milk whey proteins is different. However, it is reported that the effect is pH dependent and bovine whey protein is more soluble than camel whey protein. Poorer stability of camel milk at higher temperatures (120–140 °C) compared to bovine milk has been reported to possibly be due to lack of β-Lg and presence of smaller amounts of κ-casein. Heat treatment at 65 °C/30 min of camel, cow and buffalo milk does not affect lysozyme and LF contents but the protective proteins for microbial factors such as Ig lose their activity [14].

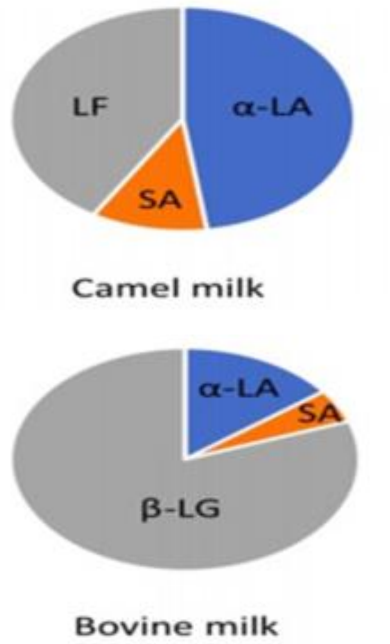

Figure 1. Distribution of the main whey proteins in camel and bovine milk (Omar *et al.* 2016).

In bovine milk β-Lg ensures highly viscoelastic absorbed surface layers due to high packing density and strong intermolecular interactions whereas adsorbed casein layers have a looser, more mobile structure. Therefore, the effect of β-Lg lack in camel milk on the quality of milk powder and other dairy products needs to be studied. Thermal treatment of camel milk in the range of 63–90 °C for 30 min and also 72 °C for 15 s resulted in reduced rennetability of camel milk. A move in gelation time happens as a result of temperature change from 30 to 40 °C [23].

A practically identical change is seen in rennet incited gelation of ox-like milk because of progress in pH. This could be because of the higher measure of hydrophobic casein, for example β-casein, in camel milk than ox-like milk [16, 26]. A synergetic effect of $CaCl_2$ addition up to 20 mg/100 ml of camel milk and thermal treatment of camel milk, in reducing rennet clotting time using bovine chymosin was indicated by Hailu *et al.* (2016) [23], however, reported that the effect of $CaCl_2$ on camel milk gelation time using camel chymosin is pH dependent and the effect was observed at pH 6·3. LF in camel milk is stable at low pH and heat treatment, making it a good preservative for maintaining food products [1].

Enzymatic hydrolysis of milk proteins enhances the functionality through the release of peptides with lower MW, different hydrophobicity and solubility properties and an increased number of ionisable groups. High hydrolysis of proteins by endo-peptidase enzymes result in less amount of free amino acids for better bioavailability. The extent of hydrolysis of enzymes determines the digestibility of the proteins via the availability of free amino acids in the product. The camel caseins contain a higher number of potential pepsin cleavage sites in their primary structure [37]. Camel milk β-casein was highly degraded by pepsin but resistant to chymotrypsin, trypsin and papain [37], therefore, pepsin can be used for modification of camel milk protein properties. Camel αS1-casein was hydrolysed more professionally by trypsin, chymotrypsin or papain in comparison to β-casein, [37]. The kinetics of camel milk κ-casein hydrolysis is similar to bovine milk κ-casein hydrolysis.

However, casein accumulation in camel milk to induced gelation is observed after >95% of the κ-casein has been hydrolysed by camel chymosin [23].

The heat stability of camel milk whey is decreased at the iso-electric point (4·5 pH) as a result of reduced solubility because of less electrostatic repulsion between proteins. The pattern of casein demineralization in camel milk is different from that of bovine milk casein, in that it is initiated at around pH 5·8 but starts already at the beginning of acidification in bovine milk casein.

3.1. Texture, gelation and foaming properties of proteins of camel milk: Proteins in food contribute to food quality and stability by forming interfacial films to stabilize emulsions and foams as well as by interacting with each other in a network to form foams, edible films and ensure thermal stability. Caseins have a flexible and disordered structure that results in low viscoelastic properties, while the globular whey proteins (lysozyme, β-Lg, bovine SA, α-La) provide surface active properties (foams and films with high rigidity) for the products.

The gelling and thickening properties of whey proteins are due to unfolding and denaturation followed by accumulation. The obscurity of β-Lg in camel milk led to protein denaturation occurring at a decreased temperature compared to bovine whey protein.

At a pH value of 5·0 poor and unstable emulsions are formed from camel milk whey protein as a result of partial denaturation of the protein and resulting aggregation. In bovine milk β-Lg is chiefly involved in aggregation caused by thermal treatment and the lack of β-Lg can thus partially explain why camel milk whey protein behaves differently. Laleye *et al.* (2008) [33] reported that camel milk whey can form stable foams at pH 7, which could provide a basis for formulation of foods with high nutritional value and appealing functional features.

3.2. Specific health effects of camel milk proteins: An variety of biologically active compounds can be gotten from milk and milk items which gives a chance to battle different illnesses. The nearness of β-Lg in camel milk (like human milk) focuses to camel milk being better ready to substitute human milk for baby diet detailing than bovine milk [30, 37].

The presence of whey protein components in higher amounts in camel milk [18, 28] might provide a qualified functional advantage to camel milk consumers.

In Egypt, the Bedouins use camel milk to treat diarrhea (personal observation). Camel milk immunoglobulin (IgG) and secretory immunoglobulin A (sIgA) were purified and their neutralization activity against bovine [13] or human [15] rotavirus was studied. Individual camel (*Camelus dromedarius*) colostrum and normal milk samples were tested for the presence of antibodies to rota - and coronaviruses. All samples were negative for anticoronavirus antibodies; while some of colostrum and milk samples had specific antibodies to rotavirus. The antirotavirus activity, i.e., antibody titer in colostrum, was strong due to IgG, while sIgA in normal milk was high. This indicates that raw camel milk is considered a strong viral inhibitor to human rotavirus. Temporarily, the high titer of sIgA against rotavirus reflects that she - camel mammary glands are able to synthesize a high concentration of such type of immunoglobulin as a defense factor.

These findings may elucidate the reason for use of camel milk as a remedy to treat diarrhea by camel herdsmen [11].

Immunoglobulins from camel milk are also very important therapeutically because of their unique property of containing only two heavy chains, as the light chains are absent.

Because of this reason, most of these immunoglobulins from lactating camel can pass within the milk; therefore, theseimmunoglobulins are remain available in the camel milk. Moreover, heavy chain of immunoglobulins are currently using in the immune therapy for patients with various disorders such as cancer, multiple sclerosis, and Alzheimer's disease.

The changes in the concentration of insulin in Egyptian dromedary camel milk were monitored during the first 5 months of lactation. The concentration of milk insulin was assessed in camels from different four locations in Matrouh governorate, Egypt. As well, the association between the content of milk insulin and the concentration of milk protein was evaluated. Results showed that the lactation period significantly affected the concentration of milk insulin.

The maximum level (1856.8 ± 804.4 µU/ml) of insulin was recorded in colostrum at 0 hr. (the first suckling after parturition). During the normal milk period, the mean concentration of insulin was 55.1 ± 33.2 µU/ml without significant difference due to the sampling time. The concentration of insulin in colostrum and milk of camels was considerably higher than blood-serum insulin. The level of milk insulin in both colostral and normal milk periods was not associated with serum insulin. Significant differences were seen in the insulin substance of camel milk tests, which gathered from four areas. The most elevated substance of insulin was in milk of camels that accepting concentrate diet, while the least one was in milk gathered from camels touching local fields. The connection among insulin and protein substance of camel milk was not noteworthy. Abou-Soliman (2017) [3].

Furthermore, camel milk also contains insulin-like protein, which is relied upon to do hostile to diabetic action. It likewise contains higher extent of zinc when contrasted with the zinc level present in the milk from different sources, for example, cow, which altogether improved insulin collaboration with its receptor.

Specialists have been accounted for that the amino acids sequence of insulin-like protein from camel milk is wealthy in cysteine residue, which has a comparable component of insulin group of peptides. In particular, it is essential to call attention to that mucosal surfaces are the most widely recognized pathways for medication conveyance to the people and the oral organization of insulin was bombed rehashed to go through mucosal barriers before entering into the bloodstream as it has been degraded by digestive enzymes, Rasheed (2017) [35].

Insulin-like protein from camel milk has a unique property of encapsulation inside the nanoparticles such as lipid vesicles that protect it from digestive enzymes in the stomach to reach the target. Because of this lipid encapsulation, camel milk has not been coagulated in an acidic environment of the stomach and most interestingly, it has a better buffering capacity than milk from other species such as cows, buffalo, and goat. Taken all together, these studies identify and support the use of camel milk and its bioactive gradients as possible preventive agents with a potential to inhibit the development of various conditions ranging from diabetes to cancer.

However, further studies are required to know the mechanisms behind their therapeutic actions, Rasheed (2017) [35].

Moreover, camel milk is an excellent source of α-hydroxy acids, which are very celebrated for treatment of skin disorders. Importantly, α-hydroxy acids are also frequently used by cosmetic industries for manufacturing of their products for wrinkles treatment as well as for soften of skin, and for overall improvement of the skin quality. Reports have shown that total protein contents including whey proteins in camel milk are significantly more than milk from other sources, this might be the reason for its effect on reducing risk for the onset of disorders such as diabetes, heart disease, and cancer.

Colostrum from bovine and camel changes in composition; SA is more rich in camel colostrum whereas β-Lg is the main whey protein present in bovine colostrum. Camel colostrum can thus be proposed to have other health benefits (i.e. immune factors) compared to bovine colostrum. Hydrolysis of camel β-casein by chymotrypsin results in increased antioxidant properties and inhibition of ACE, which suggests camel milk casein as a natural anti-hypertensive agent similar to what can be obtained from bovine milk.

Camel milk has antioxidant properties as a consequence of its high vitamin C contents which helps to control tissue damage [1]. The casein macro peptides (CMP) released as a result of the hydrolysis of κ-casein have functional properties in binding cholera enterotoxins and *E. coli*, inhibit bacterial and viral adhesion, modulate immune activity, enhance the growth of Bifidobacteria, minimise gastric juice secretion and regulate blood flow. Enzymatic hydrolysis of proteins can release bioactive peptides with higher physiologic activity. The tripeptides Val-Pro-Pro and Ile-Pro-Pro are inhibitors of the angiotensin converting enzyme (ACE) properties of those peptides that regulate the blood pressure.

Camel milk fermented with *Lactobacillus rhamnosus* PTCC 1637 contains critical measures of peptides with ACE inhibitory and cell reinforcement properties compared with bovine milk. This difference could be attributed to the structural difference between camel and bovine milk proteins as camel milk β-casein is richer in proline, is shorter by two amino acid residues compared to bovine and its N-terminal fragment is different from that of other species.

The peptide fragment identified from βcasein N-terminal of camel milk contains opioid peptides similar to proteose peptones from bovine casein. Peptides generated by enzymatic digestion of LF have an antimicrobial potential [1], which makes it a suitable additive for food preservation. Glycosylation dependent cell adhesion molecule (PP3) found in both cow and camel milk have a similar character in preventing the infection of respiratory and gastrointestinal tract of sucking young.

Hence, the occurrence of PP3 in higher concentration in camel milk El-Hatmi *et al.* (2007) [20] might provide an added advantage to camel milk in prevention of infection. Beg *et al.* (1986) [6] indicated the presence of peptides resembling insulin in camel milk whey protein. Consumption of camel milk has been indicated to result in reduction of insulin dose for type 1 diabetic patients. In-vivo trials on rats fed milk from different mammals (i.e. bovine, goat, camel and buffalo) for type-1 diabetes showed, enhancement of the insulin level and improvement in hyperglycaemia and oxidative damage of type-1 diabetes as a result of camel milk feeding.

An antihyperglycaemic effect of camel milk has also been indicated in the review paper of Shori (2015) [39], which states that a number of studies conducted to test the effect on reducing blood glucose level and enhancing availability of insulin in the plasma showed a positive effect for camel milk compared to milk form other mammals.

Recently, Rasheed (2017) [35] explored that camel lactoferrin has ligament defensive and hostile to joint action, at it demonstrated mitigating action againstthe interleukin-1β-induced activation of human osteoarthritis chondrocytes through blocking of nuclear factor kappa B signaling events. In the same study, we also have also shown that it inhibits cyclooxygenase-2 expression and prostaglandin E2 production in stimulated human osteoarthritis chondrocytes. These novel actions of camel lactoferrin are of important to know the mechanisms behind its antiinflammatory or anti-arthritic effects.

Studies conducted by Samy and Mohamed (2015) [38] have shown that camel milk proteins can be used to treat many diseases, especially cancer. The milk proteins (casein and whey proteins) have a clear effect on the destruction of cancer cells and oxidative activity against four types of the cancer cells 1- A549 2- MCF7 3- HepG2 4-, PC3, where the proteins have a different effect of casein in their ability to destroy the cancer cells, where the sensitivity of the four types of cancer cells in order were active shark proteins stronger against the first type A549 was the least Influence of species Sold PC3 while the third type had a greater sensitivity to casein and camel milk was the least A549.

Camel's milk is characterized with different properties than cow whey proteins, and it is an important source for milk in the desert areas. Camel milk whey proteins as bioactive components of functional foods have the potential to open new market opportunities as it is well established that different functional properties can be ensured by incorporating milk proteins into various foods and medicament a lot of diseases.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

References

1. Abbas, S.; Ashraf, H.; Nazir, A., Sarfraz, L., Physico-chemical analysis and composition of camel milk. *International Researchers*, **2013**, *2*, 82–98.
2. Abderrahmane, F.; Mezmaze, F.; Chekroun, A.; Saidi, D., Kheroua, O., In vitro digestibility of the dromedary whey proteins: potential uses in infant milk allergies. *International Journal of Pharmacy and Pharmaceutical Sciences*. **2015**, *2*, 115-120.

3. Abou-Soliman, N.H.I. and Elmetwaly, H.A., Milk insulin content of egyptian lactating camels. *International journal of food and nutrition sciences*, **2018**, *7*(2), 52-57.
4. Barbour, E.K., Nabbut, N.H., Frerichs, W.M., Al - Kakhi, H.M., Inhibition of pathogenic bacteria by camel's milk: Relation to whey lysozyme and stage of lactation. *Journal of Food Protection*, **1984**, *47*, 838 – 840 .
5. Beg, O.U., Von Bahr - Lindstrom, H., Zaidi, Z.H., and Jornval H. 1985 . The primary structure of α-lactalbumin from camel milk. *European Journal of Biochemistry*, **1985**, *147*, 233 – 239.
6. Beg, O.U., Von Bahr - Lindstrom, H.; Zaidi, Z.H. and Jornval, H., A camel milk whey protein rich in half - cystine: Primary structure, assessment of variations, internal repeat patterns, and relationships with neurophysin and other active polypeptides . European Journal of Biochemistry, **1986**, *159*, 195 – 201.
7. Bertrand M-E, Turgeon, S. L., Improved gelling properties of whey protein isolate by addition of xanthan gum. *Food Hydrocolloid*, **2007**, *21*(2),159-66.
8. Carlsson, A., Bjorck, L., Persson, K., Lactoferrin and lysozyme in milk during acute mastitis and their inhibitory effect in Devotest P. *Journal of Dairy Science*, **1989**, *72*(12), 3166 – 3175 .
9. Duhaiman, A.S. 1988. Purification of camel milk lysozyme and its lytic effect on *Escherichia coli* and *Micrococcus lysodeikticus*.*Comparative Biochemistry and Physiology*, **1988**, 91B, 793 – 796 .
10. Ejtahed, H. S.; Naslaji, A. N.; Mirmiran, P.; Yeganeh, M. Z.; Hedayati, M.; Azizi, F.; Movahedi, A. M., Effect of Camel Milk on Blood Sugar and Lipid Profile of Patients with Type 2 Diabetes: A Pilot Clinical Trial International Journal of Endocrinol Metab., **2015**, *13*, 1-6.
11. El - Agamy, E.I., *Studies on camel' s milk*. M. Sc. Thesis, Alexandria University, Alexandria, **1983**, Egypt.
12. El - Agamy, E.I., *Biological activity of protective proteins of camel milk against pathogenic and non pathogenic bacteria and viruses*. Ph.D. Thesis, Alexandria University, Alexandria, **1989**, Egypt.
13. El - Agamy, E.I., Camel colostrum. II. Antimicrobial factors . Proceedings of the Workshop on Camels and Dromedaries as Dairy Animal, *Nouakshott, Mauritania*, 24 – 26 October, **1994**, 177 – 180.
14. El - Agamy, E.I., Effect of heat treatment on camel milk proteins with respect to antimicrobial factors: a comparison with cows' and buffalo milk proteins. *Food Chemistry*, **2000a**, *68*, 227 – 232 .
15. El - Agamy, E.I., Detection of specific immunoglobulins to human Rotavirus in camel colostrum and normal milk. In: *2nd International Camelid Conference: Agroeconomics of Camelid Farming*, Almaty, Kazakhstan, **2000b**, 8–12 September.
16. El - Agamy, E.I., Camel milk. In: Handbook of Milk of Non - Bovine Mammals, edited by Park, Y.W., and Haenlein, *G.F.W.Ames*,Iowa:Blackwell Publishing, **2006**, 297 – 344.
17. El-Agamy, E. I., *Bioactive components in camel milk*. In Bioactive Components in Milk and Dairy Products. Y. W. Park, ed. Wiley Blackwell, Oxford, **2009**, UK.
18. El - Agamy, E.I., Nawar, M.A., Nutritive and immunological values of camel milk: A comparative study with milk of other species. In: *2nd International Camelid Conference. Agroeconomics of Camelid Farming*, Almaty, Kazakhstan, **2000**, 8 – 12 September.
19. El - Agamy, E.I.; Ruppanner, R.; Ismail, A.; Champagne, C.P., Assaf, R., Purifi cation and characterization of lactoferrin, lactoperoxidase, lysozyme and immunoglobulins from camel's milk. *International Dairy Journal*, **1996**, *6*, 129 – 145 .
20. El-Hatmi, H.; Girardet, J.; Gaillard, J.; Yahyaouia, M., Attia, H., Characterisation of whey proteins of camel(Camelus dromedarius) milk and colostrum. *Small Ruminant Research*, **2007**, *70*. 267–271.
21. El-Hatmi, H.; Zeineb J.; Salhi, I.; Aguibi, A.; Nadri, A., Khorchani,T., Comparison of composition and whey protein fractions of human, camel, donkey, goat and cow milk. *Mljekarstvo*, **2015**, *65*(3), 159-167.
22. Felfoul, I.; Lopez, C.; Gaucheron, F.; Attia, H. and Ayadi, M.A., Fouling behavior of camel and cow milks under different heat treatments. *Food and Bioprocess Technology*, **2015**, *8*, 1771–1778.
23. Hailu, Y.; Hansen, E.B.; Seifu, E.; Eshetu, M. and Ipsen, R., Factors influencing the gelation and rennetability of camel milk using camel chymosin. *International Dairy Journal*, **2016**, *60*, 62–69.
24. Hamers-Casterman, C.; Atarhouch, T.; Muyldermans, S.; Robinson , G.; Hamers, C.; Bajyana - Songa, E.; Bendahman, N., Hamers, R., Naturally occurring antibodies devoid of light chains. *Nature* **1993**, *363*, 446 – 448 .
25. Jelliffe, D.B., Jelliffe, E.F., *Human milk in the modern world*: Psychosocial, nutritional and economic significance, Oxford, U.K: Oxford, **1978**, University Press .
26. Kappeler, S.R., *Compositional and structural analysis of camel milk proteins with emphasis on protective proteins*, Ph.D. Thesis, Swiss Federal Institute of Technology, **1998,** Zurich, Switzerland.
27. Kappeler, S.R.; Ackermann, M.; Farah, Z., Puhan, Z. 1999 . Sequence analysis of camel (Camelus dromedarius) lactoferrin. *International Dairy Journal* **1999**, *9*, 481 – 486 .
28. Kappeler, S.R.; Farah, Z., Puhan, Z., Flanking regions of camel milk genes are highly similar to homologue regions of other species and can be divided into two distinct groups. *Journal of Dairy Science*, **2003**, *86*, 498 – 508 .

29. Kaskous, S., Importance of Camel Milk for Human Health: Review Article., *Emirates Journal of Food and Agriculture*, **2016**, *28*(3), 158-163.
30. Khan, A. A.; Al Zohairy, M. A., Mohiedein, A., Antidiabetic Effects of Camel Milk in StreptozotocinInduced Diabetic Rats". American *Journal of Biochemistry and Molecular Biology*, **2013**, *3*(1),151-158.
31. Konuspayeva, G.; Faye, B.; Loiseau, G., Levieux, D. 2007 . Lactoferrin and immunoglobulin contents in camel ' s milk (*Camelus bactrianus, Camelus dromedarius*, and Hybrids) from Kazakhstan. *Journal of Dairy Science*, **2007**, *90*, 38 – 46 .
32. Kumar, D.; Verma,, A. K.; Chatli, M. K.; Singh, R. P.; Kumar, N. Mehta, O. P. Malav. 2016. Camel milk: alternative milk for human consumption and its health benefits. *Journal of Nutrition and Food Science*, **2016**, *46*, 217–227.
33. Laleye L.C.; Jobe, B.; Wasesa, A.A.H. 2008. Comparative study on heat stability and functionality of camel and bovine milk whey proteins. *Journal of Dairy Science*, **2008**, *91*, 4527–4534.
34. Ling, K. C., Ethanol: *A Biofuel Role for Dairy Cooperatives?*: USDA Rural Development Research, **2008**
35. Rasheed, Z., Medicinal values of bioactive constituents of camel milk: A concise report. *International Journal of Health Sciences*., **2017**, *11*(5), 1-2.
36. Reiter, B.; Protective proteins in milk — biological significance and exploitation. *IDF Bull*. **1985a**, *191*, 1 – 35.
37. Saliha, S.A.Z.; Dalila, A.; Chahra, S.; Saliha, B.H., Abderrahmane, M., Separation and characterization of major milk proteins from Algerian Dromedary (Camelus dromedarius). *Emirates Journal of Food and Agriculture*, **2013**, *25*, 283–290.
38. Samy, A.M. and Mohammed, K. E., A comparative study of the effectiveness of iRAQI camel milk proteins against four types of cancer cells. *Journal of Anbar University for Science*, **2015**, *9*(2). 1-18.
39. Shori,. A.B., Camel milk as a potential therapy for controlling diabetes and its complications: a review of in vivo studies. *Journal of Food and Drug Analysis*, **2015**, *23*, 609–618
40. Sturman, J.A.; Gaull, G., Raiha, N.C.R., *Absence of cytothionase in human fetal liver: is cystine essential*? Science (N.Y.), **1970**, *169*, 74 – 79 .
41. Theorell, H., Akesson, A., Highly purified milk peroxidase. Arkiv för Kemi. Mineralogi ock Geologi **1943**, *17B*, 1 – 6 .
42. Ueda, T.; Sakamaki, K.; Kuroki, T.; Yano, I.; Nagata, S.,Molecular cloning and characterization of the chromosomal gene for human lactoperoxidase. *European Journal of Biochemistry*, **1997**, *243*, 32 – 41 .
43. Zhang, H.; Yao, J.; Zhao, D.; Liu, H.; Li, J.; Guo, M., Changes in chemical composition of Alxa Bactrian camel milk during lactation. *Journal of Dairy Science*, **2005**, *88*, 3402 – 3410 .