Acta Scientific Veterinary Sciences

Volume 1 Issue 4 November 2019

Review Article

Camel: A Medicinally Important Animal

Govindasamy Nagarajan[1]*, Shelesh Kumar Swami[2], Sharat Chandra Mehta[3], Raghvendar Singh[4], Sundaram Meignanalakshmi[5], Sellappan Selvaraju[6], Ramasamy Pourouchottamane[7], S.M.K.Thirumaran[1] and Nitin Vasant Rao Patil[8]

[1]*Southern Regional Research Centre (ICAR-CSWRI), Mannavanur, Kodaikanal, Tamil Nadu, India*

[2]*Post Graduate Institute of Veterinary Education & Research, Jaipur, Rajasthan, India*

[3]*Equine Production Campus (ICAR-NRC on Equines), Bikaner, Rajasthan, India*

[4]*ICAR-Central Sheep and Wool Research Institute, Avikanagar, Rajasthan, India*

[5]*Dept of Animal Biotechnology, Faculty of Basic Sciences, Madras Veterinary College, TANUVAS, Chennai, India*

[6]*ICAR-National Institute of Animal Nutrition and Physiology, Bengaluru, Karnataka 560030, India*

[7]*ICAR-Central Institute for Research on Goats, Makhdoom, Uttar Pradesh, India*

[8]*ICAR- Central Institute for Research on Cattle, Meerut Cantt., Uttar Pradesh, India*

***Corresponding Author:** Govindasamy Nagarajan, Senior Scientist, Southern Regional Research Centre (ICAR- Central Sheep and Wool Research Institute), Mannavanur, Kodaikanal, Tamil Nadu, India.

Received: August 28, 2019; **Published:** October 29, 2019

Abstract

In the present review the potential uses of Camel, in Medical field and industries has been discussed. Camel an even toed ungulate which lives in extreme environments such as deserts or high altitudes, serves as model for studying innate immune response and host for production of antivenom. Camel milk has distinct therapeutic benefits, such as anti-diabetic, anti-toxic, anti-viral, antibacterial, anti-rheumatoid arthritis, anticancer, and wound healing activities. Both caseins and whey proteins of camel milk possess bioactive peptides with significant radical-scavenging activities and may serve as potential source of nutraceuticals or therapeutic peptides for prevention and treatment of oxidative stress-associated diseases. Fermented camel milk has probiotic potential including tolerance to high bile salt concentration, low pH, and antimicrobial activity against wide range of food-borne pathogens. Cameline Ovulation Inducing Factor (OIF)present in the seminal plasma induces ovulation at similar rates like GnRH. Novel cold adapted endoglucanase (CelCM3) from the microbes inhabitating the camel rumen, is having 50% activity at 4 °C and exhibited resistance to metal ions, non-ionic detergents, urea and organic solvents, promoting its usefulness in the biochemical protocols, which warrant cold temperature. Camel urine has anticancer and antiplatelet activity and Canavanine secreted in camel urine is a potent inhibitor of cancer cells. Camel meat is considered as a functional food which serves as a remedy for fever, asthma and sciatica.

Keywords: Dromedary Camel; Heavy Chain Antibodies; Rumen Microbes; Milk; Urine; Meat Animal

Introduction

The *Camelidae* family (order: Artiodactyla) presently is having six species: dromedary (*Camelus dromedarius*), Bactrian camel (*Camelus bactrianus*), llama (*Lama glama*), guanaco (*Lama guanicoe*), alpaca (Lama pacos) and vicuna (*Lama vicugna*). Camelids are well known for their adaptation to live in extreme environments such as deserts or high altitudes, the harsh conditions- cold, hot, arid, and poor grazing- of deserts or semi-deserts, these mammals have gained many inherent unique abilities and attributes. Storage of energy in the humps and abdomen in the form of fat, favours

these animal species to survive long periods without any food or water. In spite of warm blooded animal, the body temperature of camel ranges from 34 to 41o C throughout the day [1]. When compared to other ruminants, blood glucose levels in camels are having the double level of blood glucose [2]. In spite of tolerating the high dietary intake of salt (eight times more than cattle and sheep), Camelids could not suffer from diabetes or hypertension [3].

Despite being an active member of the food producing family of farm animals, the camel has for a long time remained the most neglected animal in terms of its improvement and scientific research. The versatility of camel to survive and perform in the hard arid and semiarid regions and its unique physiological system should motivate the researchers to study it more closely to further exploit its potential [4].

Al Jassim and Sejian [5] proposed that camel is a peculiar mammalian species. Owing to their unique characteristics related to adaptation, camel would be the animal of the future at global level from the climatic change point of view. Therefore, the immediate steps need to be undertaken to find out the hidden intricacies as well as the novel therapeutics of the extraordinary wonderful animal. Based on the ability to survive on any type of grasslands, camel is the animal of choice for food security during climate change. Hence, camel needs to be further explored for the scientific purpose in order to change this neglected animal species to beneficial animal species.

The present review describes the potential uses of the camels in various disciplines of biomedical sciences by virtue of the possession of various novel genes encoding wonderful diagnostics and therapeutics, which are extensively used in the detection of various infectious agents of public health importance and their corresponding remedial measures.

Medicinal uses of camel

The advanced breakthrough research in the field of genomics, proteomics and metagenomics being carried out in camels has inevitably transformed this highly neglected animal species into the medicinally important animal species.

Very recently, Ali and his team [6] quoted that camel would be a multipurpose mammal utilized for milk, sports and transport. Search and subsequent analysis of the major genes involved in the adaptation of the camel to harsh environment would be useful in the breeding programs.

Camel as a natural source of Heavy chain antibodies

Among the mammals, Camelids have the peculiar immune system. Additionally, the availability of the sequence information pertaining to various cytokine genes of the camels would make the feasibility of cameline cytokine based diagnostics and therapeutics for the various infectious diseases of human and other livestock species including camelids [7,8].

The invention of the technique of monoclonal antibody production made a breakthrough in biotechnology. The technique, devised by Kohler and Milstein, is nothing but the chemical fusion of murine spleen cells that secrete antibodies with myeloma cells that afford the new cells immortality [9]. Monoclonal antibodies generally are monospecific (they could identify only one type of antigen), and with the advent of recombinant technology, one could continuously get the production of monoclonal antibodies. In spite of having the different therapeutic uses, MAbs have some constraints such as large tissue which hinders the efficient tissue penetration and high cost of production in eukaryotic systems. These problems could be overcome by getting Fab fragments, since they are three times smaller than full-size antibodies and could be effectively generated in prokaryotic system. Indeed, the cloning and the eventual expression of Fab fragments in E.coli would not be effective due to the heterodimer nature of Fab fragments (consisting of variable regions of heavy and light chains linked by disulfide bridges). Further, expression of single-chain variable fragments (scFv) of antibody could also have the problems due to the low solubility of these fragments and they also need a linker to keep both domains together, besides the comparative lower affinity of scFv than Fab fragments or antibodies and the tendency to aggregate [10].

A suitable and alternative strategy to mitigate the aforementioned is expression of functional fragments of heavy chain antibodies (hcAb), which are naturally present in the sera of the only one mammal. i.e. Camels. Camelids have three subclasses of functional IgGs in their sera. IgG1 is a heterodimer possessing he¬avy and light chain homodimers, where as IgG2 and IgG3 have only heavy chains and hence are popularly known as heavy chain antibodies (hcAbs). In addition to constant domains CH2 and CH3, heavy chains of hcAbs contain va¬riable domains called VHHs but no CH1 domain as in the case of regular antibody [11] and the elongated hinge region linking VHH and CH2 regions is made up of repeated residues of proline, lysine, glutamine or glutamic acid. Therefore, the structure of the hinge region in hcAbs is more rigid

and the distance between two binding domains is greater, when compared to the conventional IgGs [12]. Expression of antigen-binding fragments of conventional antibodies in the form of Fab or scFv fragments requires the separate cloning of heavy and light chains and it is time consuming process. But, in the case of heavy chain antibodies, their active antigen-binding fragments could easily be cloned and eventually expressed in the form of VHHs or nanobodies™. Due to the possession of the only one polypeptide chain, these VHHs afford the following merits when compared to the fragments of full-size antibodies and their fragments,

- Poor immunogenic nature of VHHs in human beings due to the sharing of high sequence homology between the genes encoding VHHs and the genes belonging to the human VH families 3 and 4 [13];
- Due to the possession of only one domain, it is very easy to clone and express VHHs in large quantities using different prokaryotic and eukaryotic expression systems [14];
- Owing to the inherent nature of high variability of length and sequence, VHHs could recognize a variety of epitopes, located not only on the surface of a protein [15], but also hidden deep in the clefts [16]. VHHs have also been known for their detection of a wide range of epitopes, starting from small haptens [17] to binding sites of enzymes [18];
- Due to the small size, VHHs have the ability to penetrate the barriers such as the blood-brain barrier and bind hidden pitopes, which could not be reached by conventional antibodies [19];
- VHHs are further well known for their high solubility and stability even in denaturing conditions or high temperatures [17].

Being the small in size and more stable, HCAbs possess peculiar merits in various medical and biotechnological applications [20]. Zoonotic diseases such as Listeriosis. Anthrax, Trypanosomosis, Influenza, FMD and Rabies could effectively be treated by means of broadly neutralizing antibodies (bNAbs) from the camelids [21].

Camel as a model for studying innate immune responses

The camel is a comparatively hardy animal and is less prone to most of the common dreadful infectious diseases of other livestock species such as trypanosomiasis [22] and brucellosis [23]. Regarding the viral diseases, only species specific viral infections such as camelpox [24] and contagious ecthyma [25] have been reported in Indian Dromedary camels. Camels have also been known to get the infection with foot and mouth disease, but no naturally occurring clinical cases seem to occur [26]. It is speculated that the camel's immune system especially the innate immunity could play a very crucial role as innate immunity is promptly activated after recognition of the diverse repertoire of microbial pathogens. Innate immune cells express various pattern-recognition receptors (PRRs), which recognize signature molecules of pathogens. Several classes of PRRs such as Toll like receptors (TLRs) recognize various PAMPs in various cell compartments and trigger the release of inflammatory cytokines and type I interferons for host defense. Further TLRs also play important role in cell-signaling for activation of both innate as well as adaptive immune response.

From India, Dahiya and his team [27] carried out the cloning and sequence analysis of Toll-like receptor 2 (TLR2) gene of old world camelids and it was found out that interestingly, the amidation motif is present in camel (Dromedary and Bactrian) TLR2 only, and the TIR domain is absent in Dromedary camel TLR2. It was further concluded that this information would be useful for the immune functions associated with bacterial infection of camels.

Camels thus seem to be an important model for our understanding of the evolution and of the role of genetic diversity in immune functions, especially in the context of unique features of their immunoglobulin and T-cell receptor genes [28,29].

It is well known that the roles of TLRs and their association with disease resistance and susceptibility have been well established in man. In the similar way, being the naturally resistant to most of the infectious diseases of common livestock species, camels would be the ideal animal model for studying the innate immunity and the corresponding TLRs.

Camel as a host for the production of antivenom

In comparison to horses, camels are also equally smart for the handling, immunization and bleeding; the quantum of blood is almost equal to or more, that from a horse [30]. Further, the peculiar physicochemical properties of camelid IgG affords promising possibilities for the improvement of the clinical effectiveness of antivenom treatment [31]. Presently, the antivenoms available are known to cause adverse reactions of either anaphylactoid or pyrogenic in 60e80% of patients receiving anti venom in India [32,33].

To overcome these public health issues, the camel would be alternative host for the generation of antivenom. Herrera and his team [34] concluded that Camel IgG is less immunogenic and less likely to activate the complement cascade than ovine or equine IgG suggesting that patients receiving Camelid IgG antivenom would suffer less from the anaphalactoid and serum sickness adverse effects. Further, the unusual thermostable property of camelid IgG could also be exploited to prepare antivenom that remains efficacious after room temperature storage in rural parts of the world [35].

Owing to the beneficial properties of Camelid IgG antivenom, Darvish and his team [36] did the Successful immunization of camel with Iranian *Hottentotta saulcyi* scorpion venom and evaluated the protective effect of a Nanobody (Nb12) against whole soluble venom injected in mice at 2 LD values in pre-incubated & challenge rescue experiments. *Hottentotta saulcyi*, is a medically important scorpion species, which is responsible for harmful toxic effects in Iran. Heavy chain-only antibodies (HC-Abs) camelid antivenom could be considered as a useful serotherapeutics instead of the currently available treatment for scorpion envenomation [37].

From India, Tanwar and his team [38] carried out the experiments on Production and preclinical assessment of camelid immunoglobulins against *Echis sochureki* (North Indian Saw scaled viper) venom from desert of Rajasthan.

Therapeutic uses of camel milk

When compared to the milk of other dairy animals, camel milk has been reported to cure severe food allergies in children and diabetes [39]. Furthermore, camel milk is suggested to exert a number of therapeutic activities [40]. Numerous studies suggest that camel milk has distinct therapeutic benefits, such as anti-diabetic, anti-toxic, anti-viral, antibacterial, anti-rheumatoid arthritis, anti-cancer, and wound healing activities. In addition, camel milk has been used for centuries in the Middle East, Asian and North African cultures as a natural remedy for many common health problems.

El-Fakharany and his team [41] proved that whole camel milk is having inhibitory activity against Hepatitis C Virus (HCV) under *in vivo* conditions, by reducing viral load in patient sera and converting the IgG isotype profile to Th1 immunity in HCV genotype 4.

Soliman and his team [42] concluded that camel milk had protective effects against pathogenicity induced by *E. coli* and *S. aureus* in Wistar rats.

Khan and Alzohairy [43] demonstrated that administration of camel milk in CCl4 induced acute liver toxicity is having hepatoprotective effects.

Camel milk possesses the property to reverse the Cyclophosphamide (CYP) - induced leukopenia and weight loss in mice. Moreover, it also helps in the recovery of important antioxidant enzymes such as SOD and CAT that are important players in the innate immune responses [44].

Both caseins and whey proteins of camel milk possess bioactive peptides with significant radical-scavenging activities and thus herald a fascinating opportunity for their potential as nutraceuticals or therapeutic peptides for prevention and treatment of oxidative stress-associated diseases [45].

Arab and his team [46] described the anti-inflammatory actions of camel milk (CM) in Adjuvant arthritis and air pouch edema models in rats. These promising effects were mainly linked to the inhibition of MAPK pathway, which controls the synthesis of proinflammatory signals and the CM consumption would be an adjunct approach for the management of rheumatoid arthritis.

The high amount of digestion resistant insulin and high level of antioxidants as anti-inflammatory factors are the possible explanation for anti-diabetic effect of camel milk [47].

Under *in vitro* conditions, using the camel milk, Ayyash and his team [48] evaluated its antineoplastic activity by the mechanism of antiproliferative activity, antihypertensive activity by means of angiotensin-converting enzyme inhibition, antidiabetic activity by α-amylase and α-glucosidase inhibitions, and antioxidant activities of camel milk fermented with camel milk probiotic compared with fermented bovine milk.

Camel milk proteins (CMP) have a strong antioxidant potential that reduces the effects of oxygen free radicals and lipid peroxidation by orchestrating the overall antioxidant system to the optimum *in vivo*. Moreover, CMP is a potential stimulant in normalizing the inflammatory cytokines and restoring high levels of TNF-α mediated by NF-kB in diabetic rats. An increase in neutrophil infiltration at wound sites post CMP administration in diabetic rats speeded up the normal inflammatory events of the healing process [49].

Agarwal and his team [50] stated that camel milk is safe and efficacious in improving long-term glycemic control, with a significant reduction in the doses of insulin in type 1 diabetic patients.

The composition and molecular properties of camel milk protein is different from bovine and human milk. Camel milk has comparatively higher functional contribution to human health as a result of the unique composition of caseins and whey proteins (SA, α-LA, LF, PGRP-S, and IgG with the different variants IgG1, IgG2, and IgG3) [40].

Elbanna and his team [51] isolated and identified probiotic strains isolated from camel's fermented milk with excellent probiotic potential including tolerance to high bile salt concentration, low pH, high salt, phenol, and antimicrobial activity against wide range of food-borne pathogens and Dermatophytes. Furthermore, the *in vivo* study indicated that these strains significantly improved the innate immune system. Accordingly, due to these unique probiotic properties, both selected strains could be potentially used as probiotic starter cultures for fermented dairy foods as well as functional food and health products. Shariatikia and his team [52] carried out the research work to validate the anticancer activity of cow, goat, sheep, mare, donkey and camel milk and their casein and whey proteins against MCF7 cell line. Based on the results obtained, it was concluded that mare, camel and donkey milk could be the ideal therapeutics to fight against breast cancer cells.

Krishnankutty and his team [53] found out that Camel milk possesses antiproliferative effects on human colorectal HCT 116 and breast MCF-7 cancer cells by means of augmenting autophagy.

Cameline ovulation inducing factor (OIF)

From the reproduction point of view, among the mammalian species, they could be either spontaneous or induced ovulators depending upon the mechanism involved in the ovulation. In the case of spontaneous class (e.g., human, sheep, cattle, horse, pigs, and most rodents), the ovulation happens at the regular intervals and is dependent on the level of circulating estradiol. But, in the case of induced ovulation category (e.g., rabbits, ferrets, cats, and camelids), the process of ovulation is highly correlated with the mating by the male counterpart. In addition to auditory, visual, olfactory, and mechanic stimuli, a biochemical component viz., Ovulation inducing factor (OIF) present in the semen of male counterparts of the induced ovulators is also responsible for the induction of ovulation. In camelids, when the seminal plasma(SP) is administered either through intramuscular or intrauterine route, SP is capable of inducing the preovulatory luteinizing hormone (LH) surge followed by ovulation and subsequent formation of corpus luteum [54].

Meriem and his team [55] concluded that the OIF is highly abundant in dromedary camel seminal plasma and was identified as a β-Nerve Growth Factor "Cam-β-NGF". It was also found out that intramuscular administration of Cam-βNGF induces ovulation at similar rates like GnRH. Additionally, the quantification of β-NGF in seminal plasma and the relationship between its concentration and sperm quality warrants further investigation. Being the induced ovulator, the OIF from camel could be used for the induction of ovulation in other common livestock species.

Camel rumen as a reservoir for the industrially important microorganisms and novel enzymes

Owing to this beneficial nature of camel from the global warming point of view, it is speculated that the rumen of the camel could possess different industrially important microorganisms.

Researchers at ETH Zurich and the University of Zurich have measured methane production in three types of camelids with the Zurich Zoo and private camel keepers and they reported that camels release less methane when compared to sheep and cow in relation to their body size. The results of Zurich researchers showed that camel need less feed and release less methane than our domestic ruminants and have a lower metabolism. The lower metabolism of camels helps them to manage in areas with a shortage of food – desert and barren mountain regions [56].

Similar to ruminants, camels also harbour diversified rumen microbes such as bacteria, archaea, protozoa and fungi to assist the degradation of the biomass from the plant sources [57].

St-Pierre and Wright [58] stated that in comparison to ruminants, tylopods are well known to have higher productivity even on the consumption of poor quality forages and lower emission of enteric methane. As foregut fermenters, camels and ruminants behave in the similar way from the physiological point of view but in the anatomical feature of the digestive tract, tylopods differ in possessing three chambered stomach instead of four chambered stomach as in the case of ruminants.

As far as the feeding behaviour of camel is concerned, camel is primarily a browser and secondarily a grazer. Generally, dromedaries graze a broad spectrum of fodder plants anging from thorny bushes, halophytes and aromatic species, which are commonly neglected by other plant eaters. Camels feed on a variety of plants that usually afford balanced nutrients [4].

The glycoside hydrolases (GHs) harboured by the rumen of the camels exhibited an average of 70% sequence homology with that of bovine rumen carbohydrate-active enzymes (CAZymes) [59] and this information led to the opinion that a number of the enzymes would possess interesting biochemical properties.

Recently, Ghadikolaei and his team [60] cloned and characterized a novel cold adapted endoglucanase (CelCM3) from the microbes inhabitating the camel rumen. Surprisingly, the novel enzyme was having 50% activity at 4°C and exhibited resistance to metal ions, non-ionic detergents, urea and organic solvents, promoting its usefulness in the biochemical protocols, which warrant cold temperature. These findings have motivated the researchers that rumen of the camel would be the largest source novel enzymes with an unknown utility which could be extrapolated for the betterment of various biotechnological applications such as biofuel and food processing industries.

Ariaeenejada and his team [61] produced a novel recombinant thermostable xylanase enzyme; named PersiXyn1 using the DNA template extracted from camel rumen metagenomic samples in E. coli strains. The enzyme was having 80% of its maximum activity in the pH 8 and temperature 40 °C for 1 h. This finding also proves the usefulness of camel microbiome for discovering novel thermostable enzymes with wide utility in agriculture and industries.

Pyrosequencing based metagenomics was applied to camel rumen sample. Taxonomic analysis of metagenomic reads revealed that Bacteroidetes (55.5%), Firmicutes (22.7%) and Proteobacteria (9.2%) phyla were the predominant camel rumen taxa [62].

Pyrosequencing of 16S rRNA gene amplicon was carried out to find out the structure of the microbiome inhabiting the camel rumen. Bacteroidetes (51%), Firmicutes (31%), Proteobacteria (4.8%), Spirochaetes (3.5%), Fibrobacteres (3.1%), Verrucomicrobia (2.7%), and Tenericutes (0.95%) were the major genera. Further analysis of microbial community using the solid and liquid fractions of rumen digesta showed that members of Fibrobacter, Clostridium, Ruminococcus, and Treponema were prevalent in the solid fraction, where as the enrichment of the members of *Prevotella, Verrucomicrobia, Cyanobacteria* and *Succinivibrio* was observed in the liquid fraction. These findings concluded that the microbes possessed by the rumen of the camel were structurally identical and compositionally different from that of cow. The reason for the peculiar nature of the camel rumen microbes microbiome that differentiated it from those of other ruminants was the significant enrichment for cellulolytic bacteria [63].

Two cultures of anaerobic fungi were isolated from the rumen of an Indian dromedary. Phylogenetic analysis was carried out based on the internal transcribed spacer (ITS) and large-subunit (LSU) regions of the rRNA locus. It was found out that these two fungal isolates were identical at nucleotide level and formed a separate clade within the anaerobic fungi (phylum Neocallimastigomycota). But the analysis based on the morphology revealed that these fungi were distantly related to *Piromyces* sp. and nearer to the polycentric Anaeromyces clade, and therefore, new genus and species *Oontomyces anksri* gen. nov., sp. nov. were assigned. This finding also highlighted that this fungus could be a species specific i.e., camel specific [64]. Rabee and his team [65] used an Internal Transcribed Spacer 1 (ITS1) clone library to find out the anaerobic rumen fungi in camel and to evaluate their potential to produce cellulase and xylanase *in vitro*.

Hepcidin

The hepatocyte of the liver produce antimicrobial peptide and is popularly known as Hepcidin. Hepcidin is a beta - defensin-like peptide first identified in blood and human urine. Subsequently, this peptide was found out in other vertebrates ranging from fish to mammals including camel. This antimicrobial substance is a cationic peptide made up of 25 amino acids and plays a very important role in iron metabolism.

Boumaiza and his team [66] were able to produce the cysteine rich recombinant camel hepcidin in E. coli. Further, it was demonstrated that in addition to low precipitation properties, steps involved in the purification of camel hepcidin were minimal when compared to that of murine and human pepcidin purification steps. In the degradation of the iron exporter ferroportine expressed in J774 mouse macrophages, camel hepcidin behaved in the similar

was as that of human hepcidin. On the other hand, when compared to pexiganan antimicrobial peptide, the camel derived hepcidin was also equal in inhibiting the growth of *Leishmania major*. Inspire of having the only difference in the composition of two amino acids with mature human hepcidin, camel hepcidin would be good enough in the improvement of the health status of human beings ailing from iron disorders and Leishmaniasis.

Camel urine

One or the other way almost all the biological fluids from the camel possess invariably unique medicinal value. Urine of the camel is also not an exception to this fact.

Recently, Ahamad and his team [67] validated the anticancer and antiplatelet activity of camel urine. It was found out that similar to cattle, sheep and goats, the metabolites such as canavanine, were also excreted in the urine of camel but with high percentage. Canavanine is an arginine analog and is a metabolite of amino acids and urea metabolism. Canavanine is a potent inhibitor of cancer cells where as benzenepropanoic acid exhibit the antiplatelet activity of camel urine. The findings of this study highlight the medicinal value of bovine and cameline urine with extended biological activities in the near future.

Camel as an ideal model in biomedical research

For the purpose of surviving in extremely harsh conditions having long periods of water scarcity, high scorching temperatures with direct sunlight in summer as well as very cold temperatures in winter, the body of the camel would produce different kinds of heat shock proteins viz., Hsp70 and 90[68], αB-crystallin (CRYAB) and HSPA6.

Camel Hsp90 plays a vital role in cell growth and differentiation, apoptosis, signal transduction, cell-cell communication as well as the rescue of cell's protein from the deleterious effects of heat inactivation and denaturation [69].

αB-crystallin (CRYAB or HSPB5) is also a kind of chaperone produced upon stress, CRYAB was originally found out in the lens and subsequently, it was seen in different tissues during heat stress [70,71]. CRYAB acts by binding to partially unfolded proteins by the mechanism of ATP-independent manner in order to keep such proteins in liquid state and thereby preventing the aggregation of the proteins at intracellular level [72].

As far as HSPA6 is considered, it is a HSP70 chaperone that is produced upon the extreme severe cellular stress. The function of HSPA6 is highly regulated and is a homologue of HSP70 [73]. Induction of HSPA6 has been employed as a tool for detection of cytotoxicity [74,75].

When compared to human HSPA6, the formation of camel HSPA6 in the glycoform was very quick and stable under normal and stress culture conditions. It was proposed that to escape from the stressful environment, camelids have the mechanism of efficient glycosylation of HSPA6 [76].

Yurinskaya and his team [77] concluded that the recombinant forms of both human and camel HSP70 would have the potential ability to alleviate endotoxin induced generation of reactive oxygen species and inhibit the human neutrophil apoptosis.

Bou^aouda and his team [78] concluded that adaptive heterothermy in the Arabian camel is nothing but the combination as well as the interaction of three factors throughout the daily light–dark cycle: heat stress, water restriction, and the level of food intake.

Therefore, camels are interesting species for studying specific roles of not only HSP proteins relevant to normal cellular physiology but also various unique and novel proteins expressed by them. The novel proteins of camel origin would be exploited in transgenic research.

Camel as food animal

Meat production from camel is becoming progressively important because of its low fat content and relatively high polyunsaturated fatty acid content [79].

According to Kurtu [80], camel meat is traditionally used as a remedial measure to treat the ailments such as hyperacidity, hypertension, pneumonia, and respiratory disease as well as an aphrodisiac.

Stable and acceptable camel meat emulsion could be prepared from camel meat. Camel meat emulsion sausages would be considered as the ideal alternative for beef particularly in Asian and African countries [81].

Camel meat is also equally comparable with other red meats (beef, mutton, chevon and chicken) possessing high water content, low fat & ash and equal level of protein [79]. As far as the mineral content is considered, camel meat and the other four red meats had the equal level of mineral with the exception of more sodium in the camel meat [82]. The ratio of essential amino acids to non-essential amino acids in the camel meat was also equally comparable with that of beef, mutton and chevon [83].

Kadim and his team [84] concluded that the shoulder muscles had better quality attributes than leg muscles. Longissimus thoracis muscle proved to be one of the best quality muscles for marketing.

Consideration and Conclusion

Camel thrives under harsh conditions and adapts itself to climate change, makes camel as a unique animal. Camel milk, meat, urine and seminal plasma has lot of medicinal properties and camel as an animal serves as model for studying innate immune response and host for antivenom production. Fermented camel milk has probiotic potential and rumen microbes of camel produce industrially important enzymes. Hence there is an increasing demand for camel products and camel. Much attention has not been paid on camel research and camel rising. Hence multidisciplinary research and holistic approach is needed to elucidate the medicinal and industrial potential of camels. In future there will be increased demand for camels when compared to other livestock species, therefore it is essential to understand the farming conditions of camel and their meat and milk production. Commercial dairies have to be raised for processing camel milk. When many animals can be farmed camels can also be commercially farmed.

Competing Interests

The authors declare that they have no competing interests.

Acknowledgements

The authors are thankful to the supporting staff and contractual workers of ICAR-NRC on Camel Bikaner, Rajasthan, India in the preparation of the manuscript.

Bibliography

1. Schmidt-Nielsen K., *et al*. "Desert Animals. Physiological Problems of Heat and Water". Oxford University Press (1964).
2. Al-Ali A., *et al*. "A comprehensive biochemical analysis of the blood of the camel (Camelus dromedarius)". *Comparative Biochemistry and Physiology B* 89 (1988): 35-37.
3. Ali T. "A Manual for the Primary Animal Health Care Worker". FAOUN (1994).
4. Iqbal A., *et al*. "Feeding behaviour of camel review". *Pakistan Journal of Agricultural Sciences* 38 (2001): 3-4.
5. Al Jassim R., *et al*. "Climate change and camel production: impact and contribution". *Journal of Camelid Science* 8 (2015): 1-17.
6. Ali A., *et al*. "From Desert to Medicine: A Review of Camel Genomics and Therapeutic Products". *Frontier in Genetics* 10 (2019): 17.
7. Nagarajan G., *et al*. "Cloning and phylogenetic analysis of Interleukin-6 (IL-6) and Tumor necrosis factor-a (TNF-alpha) from Indian dromedaries (Camelus dromedarius)". *Comparative Immunology, Microbiology and Infectious Diseases* 34 (2011): 291-298.
8. Nagarajan G., *et al*. "Cloning and sequence analysis of IL-2, IL-4 and IFN-γ from Indian Dromedary camels (Camelus dromedarius)". *Research in Veterinary Science* 92 (2012): 420-26.
9. Kohler G., *et al*. "Continuous cultures of fused cells secreting antibody of predefined specificity". *Nature* 256 (1975): 495-497.
10. Worn A., *et al*. "Different equilibrium stability behavior of ScFv fragments: identification, classification, and improvement by protein engineering". *Biochemistry* 38 (1999): 8739-8750.
11. Muyldermans S., *et al*. "Sequence and structure of VH domain from naturally occurring camel heavy chain immunoglobulins lacking light chains". *Protein Engineering* 7 (1994): 1129-1135.
12. Nguyen VK., *et al*. "Functional heavy-chain antibodies in Camelidae". *Advance Immunology* 79 (2001): 261-296.
13. Deschacht N., *et al*. "A novel promiscuous class of camelid single-domain antibody contributes to the antigen-binding repertoire". *Journal of Immunology* 184 (2010): 5696-5704.
14. Harmsen MM., *et al*. "Properties, production, and applications of camelid single-domain antibody fragments". *Applied Microbiology and Biotechnology* 77 (2007): 13-22.
15. Desmyter A., *et al*. "Antigen specificity and high affinity binding provided by one single loop of a camel single-domain antibody". *Journal of Biological Chemistry* 276 (2001): 26285-26290.

16. Baral TN., *et al*. "Experimental therapy of African trypanosomiasis with a nanobody-conjugated human trypanolytic factor". *Nature Medicine* 12 (2006): 580-584.

17. Ladenson RC., *et al*. "Isolation and characterization of a thermally stable recombinant anti-caffeine heavy-chain antibody fragment". *Analytical Chemistry* 78 (2006): 4501-4508.

18. Desmyter A., *et al*. "Three camelid VHH domains in complex with porcine pancreatic a-amylase. Inhibition and versatility of binding topology". *Journal of Biological Chemistry* 277 (2002): 23645-23650.

19. Abulrob A., *et al*. "The blood-brain barrier transmigrating single domain antibody: mechanisms of transport and antigenic epitopes in human brain endothelial cells". *Journal of Neurochemistry* 95 (2005): 1201-1214.

20. Hamers-Casterman C., *et al*. "Naturally occurring antibodies devoid of light chains". *Nature (Lond.)* 363 (1993): 446-448.

21. Lafaye P., *et al*. "Use of camel single-domain antibodies for the diagnosis and treatment of zoonotic diseases". *Comparative Immunology, Microbiology and Infectious Diseases* 60 (2018): 17-22.

22. Njiru ZK., *et al*. "Detection of Trypanosoma evansi in camels using PCR and CATT/T. evansi tests in Kenya". *Veterinary Parasitology* 124 (2004): 187-199.

23. Abbas B., *et al*. "A review of camel brucellosis". *Preventive Veterinary Medicine* 55 (2002): 47-56.

24. Balamurugan V., *et al*. "A polymerase chain reaction strategy for the diagnosis of camelpox". *Journal of Veterinary Diagnostic Investigation* 21 (2009): 231-237.

25. Nagarajan G., *et al*. "Complete nucleotide sequence of the envelope gene of pseudocowpox virus isolates from Indian dromedaries (Camelus dromedarius)". *Archives of Virology* 155 (2010):1725-1728.

26. Wernery U., *et al*. "Foot-and-mouth disease in camelids". *Veterinary Journal* 168 (2004): 134-142.

27. Dahiya SS., *et al*. "Sequence analysis of the Toll-like receptor 2 gene of old world camels". *Journal of Advanced Research* 5.6 (2014): 695-704.

28. Burger PA. "The history of Old World camelids in the light of molecular genetics". *Tropical Animal Health and Production* 48.5 (2016): 905-913.

29. Plasil M., *et al*. "The major histocompatibility complex of Old World camelids: class I and class I-related genes". HLA (2019).

30. Cook DAN., *et al*. "Analysis of camelid IgG for antivenom development: serological responses of venom-immunised camels to prepare either monospecific or polyspecific antivenoms for West Africa". Toxicon 56 (2010): 363-372.

31. Harrison RA., *et al*. "The unique properties of camelid IgG have potential to improve the treatment of snake bite". *Journal of Camel Practice and Research* 14 (2007): 15-16.

32. Ariaratnam CA., *et al*. "An open randomized comparative trial of two antivenoms for the treatment of envenoming by Sri Lankan Russell's viper (Daboia russelii russelii)". *Transactions of the Royal Society of Tropical Medicine and Hygiene* 95 (2001): 74-80.

33. Kochar DK., *et al*. "Rediscovery of severe saw-scaled viper (Echis sochureki) envenoming in the Thar desert region of Rajasthan, India". *Wilderness and Environmental Medicine* 18 (2007): 75-85.

34. Herrera M., *et al*. "Factors associated with adverse reactions induced by caprylic acid-fractionated whole IgG preparations: comparison between horse, sheep and camel IgGs". *Toxicon* 46 (2005): 775-781.

35. Omidfar K., *et al*. "Studies of thermostability in Camelus bactrianus (Bactrian camel) single-domain antibody specific for the mutant epidermal-growth-factor receptor expressed by Pichia". *Biotechnology and Applied Biochemistry* 46 (2007): 41-49.

36. Darvish M., *et al*. "Development of protective agent against Hottentotta saulcyi venom using camelid single-domain antibody". *Molecular Immunology* 68(2 Pt B) (2015): 412-420.

37. Darvish M., *et al*. "Camelid antivenom development and potential in vivo neutralization of Hottentotta saulcyi scorpion venom". *Toxicon* 113 (2016): 70-75.

38. Tanwar PD., *et al*. "Production and preclinical assessment of camelid immunoglobulins against Echis sochureki venom from desert of Rajasthan, India". *Toxicon* 134 (2017): 1-5.

39. Abdul R AO., *et al*. "Differential effects of camel milk on insulin receptor signaling - toward understanding the insulin-like properties of camel milk". *Frontier in Endocrinology* (Lausanne) 7 (2016): 4.

40. Hailu Y., *et al*. "Functional and technological properties of camel milk proteins: a review". *Journal of Dairy Research* 83.4 (2016): 422-429.

41. El-Fakharany EM., *et al*. "Influence of camel milk on the hepatitis C virus burden of infected patients". *Experimental and Therapeutic Medicine* 13.4 (2017).

42. Soliman MM., *et al*. "Protective effects of camel milk against pathogenicity induced by Escherichia coli and Staphylococcus aureus in Wistar rats". *Molecular Medicine Reports* 12.6 (2015).

43. Khan AA., *et al*. "Hepatoprotective effects of camel milk against CCl4-induced hepatotoxicity in Rats". *Asian Journal of Biochemistry* 6(2011): 171-180.

44. Khan MA., *et al*. "Immune potentiating and antitoxic effects of camel milk against cyclophosphamide-induced toxicity in BALB/C mice". *International Journal of Health Science* (Qassim) 11.4 (2017).

45. Ibrahim HR., *et al*. "Potential antioxidant bioactive peptides from camel milk proteins". *Animal Nutrition* 4.3 (2018): 273-280.

46. Arab HH., *et al*. "Camel milk attenuates rheumatoid arthritis via inhibition of mitogen activated protein kinase pathway". *Cell Physiology and Biochemistry* 43.2 (2017).

47. Mirmiran P., *et al*. "Camel milk has beneficial effects on diabetes mellitus: a systematic review". *International Journal of Endocrinology and Metabolism* 15.2 (2017).

48. Ayyash M., *et al*. "In vitro investigation of anticancer, antihypertensive, antidiabetic, and antioxidant activities of camel milk fermented with camel milk probiotic: a comparative study with fermented bovine milk". *Journal of Dairy Research* 101 (2018): 900-911.

49. Ebaid H., *et al*. "Erratum to: camel milk peptide improves wound healing in diabetic rats by orchestrating the redox status and immune response". *Lipids Health Disease* 16.1 (2017): 43.

50. Agrawal RP., *et al*. "Effect of camel milk on glycemic control and insulin requirement in patients with type 1 diabetes: 2-years randomized controlled trial". *European Journal of Clinical Nutrition* 65.9 (2011): 1048-1052.

51. Elbanna K., *et al*. "In vitro and in vivo evidences for innate immune stimulators lactic acid bacterial starters isolated from fermented camel dairy products". *Science Report* 8 (2018): 12553.

52. Shariatikia M., *et al*. "Anticancer activity of cow, sheep, goat, mare, donkey and camel milks and their caseins and whey proteins and in silico comparison of the caseins". *Molecular Biology Research Communications* 6.2 (2017): 57-64.

53. Krishnankutty R., *et al*. "Anticancer Activity of Camel Milk via Induction of Autophagic Death in Human Colorectal and Breast Cancer Cells". *Asian Pacific Journal of Cancer Prevention* 19.12 (2018): 3501-3509.

54. El Allali K., *et al*. "Effect of the Camelid's Seminal Plasma Ovulation-Inducing Factor/β-NGF: A Kisspeptin Target Hypothesis". *Frontier in Veterinary Science* 4 (2017): 99.

55. Meriem F., *et al*. "Identification of β-nerve growth factor in dromedary camel seminal plasma and its role in induction of ovulation in females". *Emirates Journal of Food and Agriculture* 29.4 (2017): 293-299.

56. Dittmann MT., *et al*. "Methane emission by camelids". *PLOS One* 9.4 (2014).

57. Samsudin AA., *et al*. "Cellulolytic bacteria in the foregut of the dromedary camel (Camelus dromedarius)". *Applied Environmental and Microbiology* 78 (2012): 8836-8839.

58. St-Pierre B., *et al*. "Diversity of gut methanogens in herbivorous animals". *Animal* 7.1 (2013): 49-56.

59. Stewart RD., *et al*. "Assembly of 913 microbial genomes from metagenomic sequencing of the cow rumen". *Nature Communication* 9 (2018): 870.

60. Ghadikolaei KK., *et al*. "A cold-adapted endoglucanase from camel rumen with high catalytic activity at moderate and low temperatures: an anomaly of truly cold-adapted evolution in a mesophilic environment". *Extremophiles* 22.2 (2018): 315-326.

61. Ariaeenejad S., *et al*. "Identification and characterization of a novel thermostable xylanase from camel rumen metagenome". *International Journal of Biological Macromolecules* 126 (2019): 1295-1302.

62. Bhatt VD., *et al*. "Molecular analysis of the bacterial microbiome in the forestomach fluid from the dromedary camel (Camelus dromedarius)". *Molecular Biology Reports* 40.4 (2013): 3363-3371.

63. Gharechahi J., *et al*. "In-depth diversity analysis of the bacterial community resident in the camel rumen". *Systematic and Applied Microbiology* 38.1 (2015): 67-76.

64. Dagar SS., *et al*. "A new anaerobic fungus (Oontomyces anksri gen. nov., sp. nov.) from the digestive tract of the Indian camel (Camelus dromedarius)". *Fungal Biology* 119.8 (2015): 731-737.

65. Rabee AE., *et al*. "Community structure and fibrolytic activities of anaerobic rumen fungi in dromedary camels". *Journal of Basic Microbiology* 59.1 (2019): 101-110.

66. Boumaiza M., *et al*. "Expression and purification of a new recombinant camel hepcidin able to promote the degradation of the iron exporter ferroportin1". *Protein Expression and Purification* 115 (2015): 11-18.

67. Ahamad SR., *et al*. "Metabolomic and elemental analysis of camel and bovine urine by GC-MS and ICP-MS". *Saudi Journal of Biological Sciences* 24.1 (2017): 23-29.

68. Kregel KC., *et al*. "Heat shock proteins: modifying factors in physiological stress responses and acquired thermotolerance". *Journal of Applied Physiology* 92.5 (2002): 2177-2186.

69. Saeed H., *et al*. "The Arabian camel Camelus dromedarius heat shock protein 90α: Cdna cloning, characterization and expression". *International Journal of Biological Macromolecules* 81 (2015): 195-204.

70. Horwitz J., *et al*. "Alpha-crystallin can function as a molecular chaperone". *Proceedings of the National Academy of Sciences of the United States of America* 89 (1992): 10449-10453.

71. Carver JA., *et al*. "Alpha-crystallin: Molecular chaperone and protein surfactant". *Biochimica et Biophysica Acta* 1204 (1994): 195-206.

72. Mchaourab HS., *et al*. "Structure and mechanism of protein stability sensors: Chaperone activity of small heat shock proteins". *Biochemistry* 48 (2009): 3828-3837.

73. Noonan EJ., *et al*. "Hsp70B' regulation and function". *Cell Stress Chaperones* 12 (2007): 393-402.

74. Wada KI., *et al*. "Rapid and highly sensitive detection of cadmium chloride induced cytotoxicity using the HSP70B' promoter in live cells". *Biotechnology and Bioengineering* 92 (2005): 410-415.

75. Leung TK., *et al*. "The human heat-shock protein family. Expression of a novel heat-inducible HSP70 (HSP70B') and isolation of its cDNA and genomic DNA". *Biochemical Journal* 267 (1990): 125-132.

76. Hoter A., *et al*. "Differential Glycosylation and Modulation of Camel and Human HSP Isoforms in Response to Thermal and Hypoxic Stresses". *International Journal of Molecular Sciences* 19 (2018): 402.

77. Yurinskaya MM., *et al*. "Exogenous Heat Shock Proteins (HSP70) Significantly Inhibit Endotoxin-Induced Activation of Human Neutrophils". *Doklady Biological Science* 426 (2009): 298-301.

78. Bouaouda H., *et al*. "Daily regulation of body temperature rhythm in the camel (Camelus dromedarius) exposed to experimental desert Conditions". *Physiology Report* 2.9 (2014).

79. Kadim IT., *et al*. "A review of the growth, and of the carcass and meat quality characteristics of the one-humped camel (Camelus dromedarius)". *Meat Science* 80.3 (2008): 555-69.

80. Kurtu MY., *et al*. "An assessment of the productivity for meat and the carcass yield of camels (Camelus dromedarius) and of the consumption of camel meat in the eastern region of Ethiopia". *Tropical Animal Health and Production* 36 (2004): 65-76.

81. Mohamed HM., *et al*. "Effect of cooking temperatures on characteristics and microstructure of camel meat emulsion sausages". *Journal of the Science of Food and Agriculture* 96.9 (2016): 2990-2997.

82. Elgasim EA., *et al*. "Proximate composition, amino acids and inorganic mineral content of Arabian camel meat: Comparative study". *Food Chemistry* 45 (1992): 1-4.

83. Dawood AA., *et al*. "Nutrient composition of Najdi-camel meat". *Meat Science* 39 (1995): 71-78.

84. Kadim IT., *et al*. "Chemical composition, quality and histochemical characteristics of individual dromedary camel (Camelus dromedarius) muscles". *Meat Science* 93 (2013): 564-571.

Volume 1 Issue 4 November 2019