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Review Article

Review on Genomics, Production Potential and Usefulness of Camel as the Animal of Future

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Abstract

Food security issues are persistently emerging in proportionate to the growth of human population. This scenario demands a search for alternate and development of new food sources. Camel can therefore be the best alternative and beneficial addition to food supply chain providing milk and meat for humans. It is an imperative component of desert ecosystem with much better feed conversion ratio. Hence in arid zones, it provides more milk and meat with less consumption of feed and fodder. Moreover, Heat Shock proteins present in camel serve as molecular chaperones and strengthen its resistance capability against hostile desert environment ultimately facilitating its survival. Distinctive nutritional value of its milk is thought to have therapeutic attributes. Furthermore, camel milk inherently possesses antimicrobial agents which promote its antiviral and antibacterial capacity. Its unique adaptability and superiority over other livestock has compelled scientists for the last few decades to explore its hidden potential. Its proper breeding and farming infrastructure, well backed by scientific advancements, does not exist which need to be essentially developed and established, the initiative not possible without collaborative research efforts. Under present conditions and keeping in view the requirements of the masses, the investigative work should focus on its therapeutic, biological, and functional properties instead of pursuing trivial aspects. Successful management and efficient handling of these researchable avenues can facility efficient utilization of this animal to meet the ever-increasing food demands of the masses. This review article will highlight its wonderful adaptive features, genetic make-up, usefulness at present, and its potential for future food security.

Keywords: Adaptation Production potential; Genomics; Milk qualities; Future potential

Introduction

Camels play an imperative role in the lives of human beings. Due to their versatile adaptability and unique ability to survive in harsh environment they are successfully enjoying their living in extraordinarily hot regions of Africa, Asia, and Arabian deserts (Epstein 1971). Since prehistoric times, they have been dominantly implied for cargo, for riding as well as supplier of milk and meat to its caretakers and dependents. It ploughs the land, levels the fields, pulls and carries the carts, grinds and crushes of the different crops and their products (Marghazani *et al.* 2019). Like its live activities, various parts of its body are highly significant too. The raw material for synthesis of blankets, tents, ropes, mats and other materials for decorative purposes comes from hide and hair of camel (Faraz *et al*. 2013). It will also be worth mentioning here that its hide is principal contributor to the manufacture of large skin receptacles also called "Kuppas". These containers are mainly utilized for storage of oils and ghee. In desert locked countries it is principal source of transportation of military, their ammunition, equipment and troops. All of the above it is an integral part of nomads life where other than meeting their living requirements it is a mean of amusement in festivals when they use it for dancing and/or racing (Al-Jassim and Sejian 2015).

Due to these peculiar qualities they have emerged as highly successful and sustainable livestock species (Yam and Khomeiri 2015). Camels connected the Arabian Peninsula with the Sahara and the Levant to the Far East Asia with northern Arabia at the crossroads and improved the trade and shared the cultural heritage among these three countries (Burger 2016).

The word "Camel" is mostly used for camel-like mammals. These mammals belong to kingdom *animalia*, class *mammalia*, order *Artiodactyla*, family *Camelidae* and genus C*amelu*s which includes domestic (*Lama glama*, *C. bactrianus*, *C. dromedaries*, *Vicugna pacos*), wild (*Lama guanicoe*, *C. ferus*, *V. vicugna*), *alpaca* of South America

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(Wu *et al*. 2014; Almathen *et al*. 2016) and fossilized camels (*C. gigas*, *C. sivalensis*, *C. moreli*) (Faraz *et al*. 2019). Modern demographic history studies reported that three main species of camel are established over the last 100,000 years (Burger 2016). Thirty seven million Camelids are found worldwide approximately and 75% among them are dromedary and Bactrian (Zarrin *et al*. 2020). The classification of the *Camelidae* family is given in the Fig. 1.

On the average camel can live up to 40-50 years with an average weight range of 300-1000 kg. Their padded feet support their swift movement in desert without tumbling and dipping deep in the sand. These unusually expanded feet support much higher running speed of 65 km/h (Bhakat 2019). Their long eyelashes, ear hairs and closed nostrils is another adaptation which resists the free entry of sand during sand storms. If accidentally any sand particle/particles enter eyes and are trapped there their transparent third eyelid comes in action and dis-lodges them forthwith (Chase 2019).

Camel Distribution

About 14 million camels inhabit this world. Out of this sum 90% are dromedaries which have been mostly domesticated in the Middle East, South Asia and in the Horns of Africa. Dromedary camels dominate in the total existing population of the camels and only 700,000 are distributed in central Australia (Brim-Box *et al*. 2010; Lu *et al*. 2012). Bactrian camels on the other hand are almost 1.4 million in number, and they are mostly domesticated with minimum population in the wild in scattered places. For example approximately 1400 wild Bactrian camels inhabited deserts of Taklamakan and Gobi deserts in China and Mongolia (Faye and Bonnet 2012). Distribution status of different species of the family *Camelidae* around the globe is given in Table 1.

In Pakistan different species of camels are distributed throughout the country with variable numbers from region to region. Its widespread and universal distribution witnesses its socio-economic importance to human beings. Some important attributes which contribute to its significance and value are; as a source of meat, milk, means of transportation, source of amusement like traditional racing and dancing (Ali *et al*. 2009). Among major camel raising countries in the world Pakistan ranks at 8th position with camel population of 1 million (FAOSTAT 2015). Percentage distribution of camel population in various provinces of Pakistan like Baluchistan, Sindh, Punjab and KPK is 41, 30, 22 and 7% respectively (Faraz *et al*. 2013). Different camel breeds of Pakistan and their natural habitats with physical features are given in Table 2.

Genomic Studies of Camel

Camels have 2n=74 chromosomes and its karyotype is comprised of 32 acrocentric pairs, 3 sub metacentric pairs and 1 metacentric autosomal pairs. Among sex chromosomes the X is huge metacentric chromosome but Y is a little metacentric chromosome (Prasad *et al*. 2014). Bactrian camel has 20,821 genes with GC content of 41.3%, repeat content 30.4%, average 8 exons and 1,322 bp coding region (Wu *et al*. 2014). While Dromedary camel genome size is 2.01 GB with GC content of 41.2% and repeat content 28.4%. Alpaca genome size is 2.05 GB, with GC content of 41.4%, and repeat content 32.1% (Richardson *et al*. 2019).

Phylogenetic Analysis of Camel

Molecular evolutionary studies have revealed that the old and new world camels separated from each other about 11 to 25 mya (Kadwell *et al*. 2001). Dromedary and Bactrian (family *Camelini*) distinguished from each other about 5 to 8 mya. Molecular genetics has confirmed three species of the family *Camilini* which are *C. dromedarius*, *C. bactrianus* and *C. ferus* (Wang *et al*. 2012). The whole genome SNP data has been reconstructed for the early independent demographic history of the three Old World camel species (Fitak *et al*. 2016). When camel history was traced back to the origin of old world camelids it was also found that the first ancestor of the *Camelini* inhabited in North America (Ji *et al*. 2009; Wu *et al*. 2014). For phylogenetic analysis mitochondrial DNA was used because of its low molecular weight, small size and high mutation rate in comparison with other markers. For the phylogenic analysis of different species of camels, various studies have been conducted on Cytochrome b gene of mitochondria, an important gene for protein coding. This gene was isolated from the Bactrian camel breeds of China, Mongolia, Russia, and one wild Bactrian camel group of Mongolia (Quan *et al*. 2000; Chuluunbat *et al*. 2014). These studies demonstrated that the domestic Bactrian comes from the same monophyletic lineage as that of the wild Bactrian camels. Moreover, during another study it was also found that the most widely recognized mitochondrial haplotypes (H1, H3, and H4) were shared among Russian, Mongolian and Chinese domesticated Bactrians. It was also observed that there no distinctive geographic structure and significant relatedness among Bactrian camel breeds of these regions (Ji *et al*. 2009). Two other mitochondrial genes ATP6 and ATP8

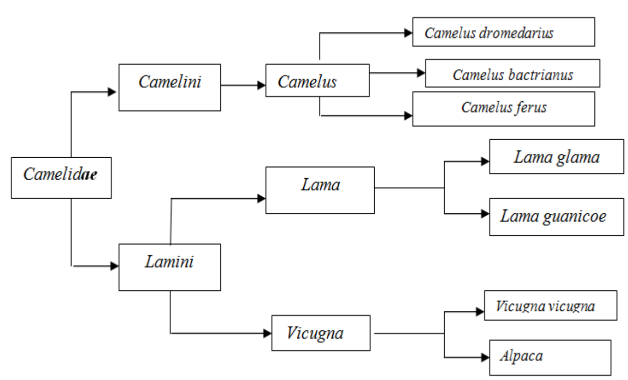

Fig. 1: Classification of *Camelidae* Family

Table 1: Distribution of different species of Camels around the Globe

Species	Habitat	References
CAMELUS		
Bactarian camels (*Camelus bactrianus*)	Central Asia (entirely domesticated)	(Ji *et al*. 2009)
Wild Bactrian camel (*Camelus ferus*)	Central Asia, northwest China, Mongolia (entirely wild)	(Reading *et al*. 1999)
Dromedary camel (*Camelus dromedaries*)	South Asia and Middle East, Horns of Africa and Asia (Entirely domesticated)	(Nelson *et al*. 2015)
LAMA		
Lama glama	Altiplano of southeast Peru and western Bolivia	(Yacobaccio and Vilá 2016)
Lama guanaco	South America	(Arzamendia and Vilá 2015)
VICUGNA		
Alpaca (*Vicugna pacos*)	Mountains of South America	(Martini *et al*. 2015)
Vicuna (*Vicugna vicugna*)	north-western Argentina, western Bolivia, and northern Chile	(Wurstten *et al*. 2014)

Table 2: Distribution of different breeds of Camels in Pakistan

Breed names	Appearance	Location	References
Brahvi	Light to dark fawn or dark colored, comparatively short stature	Chaghi district, Balochistan	(Kakar 2009)
Kharani	Light yellowish to gray color, compact body with abundance of grey and white hair	Kharan, Jhalawan, Kala	(Raziq 2009)
Makrani	Light brown but darker on neck and flanks fawn color	Makran, Kharan, Lasbella	(Isani and Baloch 2000)
Rodbari	Dirty grey to light red, comparatively slim body, short neck joined with head, humps covered with dense hair.	Makarn, Pasni, Turbat, Gawader, Panjgur, Khuzdar	(BALOCH 2002)
Ghulmani	Mostly white, tall and sturdy	Dera Ismail Khan, Zobe	(Faraz *et al*. 2013)
Lassi	Dark color on hump, shoulder and part of belly, medium size	Lasbella, Lassi, Baluchistan, Sindh	(Ahmad *et al*. 2010)
Kachhi	Fawn color, compact body with short neck	Sibi, Jacobabad	(Jasra and Mirza 2004)
Pishin	Light brown to dark brown, comparatively short stature, sturdy	Pishin, Quetta	(Marghazani *et al*. 2019)
Gaddi	Whitish color, tall, strong with massive legs	Lakki Marwat, D.I.Khan	(Faraz *et al*. 2013)
Khader	Long legged, slim, small hump, barrel shaped body	Southern NWFP, Suleiman range, Indus River	(BALOCH 2002)
Maya	Dark brown to blackish color, neck short, well build and sturdy	Tribal areas of KPK	(Khan 2004)
Kala-chitta	Mostly creamy, sometimes with darker shades.	Pabbi, Kala-chitta range, Sohawa, Salt range	(Ahmad *et al*. 2010)
Campbelpuri	Fawn color, mostly heavy weight	Potohar plateau of Attock, Chakwal, Rawalpindi, Jehlum, Sargodha, Mianwali.	(Abbasa *et al*. 2016)
Bagri (Booja)	Fawn to brown and white shades, heavy weight	Cholistan and Thal desert	(Fatima *et al*. 2019)
Mareecha (Mahra)	Chestnut to blackish shades, medium sized head with muzzle, long legs comparatively long neck	Cholistan desert, D.I.Khan	(Ali *et al*. 2018)
Dhatti (Thari)	Light to dark fawn, slim body with long legs	Thatta area in Tharparker, Mirpurkhas, Umerkot, Sanghar, Badin	(Aujla and Hussain 2016)
Brela (Thalocha)	Dark brown to light black, big, tall and strong body with massive head neck and legs	Cholistan, Jhang, Multan, Muzaffar-garh, Mianwali (Thal)	(Khan 2009)
Kharai	Dark brown to black, medium sized comparatively thin neck and legs	Kharo-chhan, Chohrjamali, coastal parts of Karachi, Thatta, Badin, Kach	(Kaurajo *et al*. 2020)
Sakrai	Reddish brown with darker neck, medium sized animal, short hair coat	Mirpur, Sakro, Sujawal, Tallukas of Thatta district.	(Shah *et al*. 2009)
Larry	Dark fawn to dark brown with heavy weight massive body, strong legs and well-developed hump	Hyderabad, Badin, banks of Indus River	(BALOCH 2002)

were also used for the phylogenetic analysis of 8 different breeds of camels which are currently inhabiting the different regions of Pakistan. All Pakistani breeds were confirmed as dromedaries (Ali *et al*. 2018).

Genetic Diversity

For the determination of genetic variability and diversity molecular markers have been applied in the past. These molecular markers described the genetic diversity between the individual Bactrian and dromedary camels (Mariasegaram *et al*. 2002; Mburu *et al*. 2003). The single nucleotide polymorphism and restriction length polymorphism are the most commonly used markers for the genetic studies of camels (Jianlin *et al*. 2004). Up to 2.95% of genetic variability was observed between domestic and wild bactrian camels in the control region of mitochondria (Silbermayr *et al*. 2010). To measure the population diversity of camels, autosomal microsatellite markers having short repetitive sequence were also applied. Microsatellite markers are generally used to decide genetic diversity inside and between camel populations (Bruford *et al*. 2003; Charruau 2012). In view of socio-topographical and ancestral contemplations, findings revealed that there is a chronic crossbreeding between various genealogical heredities which resulted in current mixture of genome among topographically distinctive ecotypes (Eltanany *et al*. 2015). Large-scale nuclear SNP analyses have not been applied in old world camelids so far. These markers are very useful alternatives to microsatellites and have been employed in many studies involving genetic diversity and relevant phenotypic traits in livestock (Goddard and Hayes 2009). Mitochondrial Cyt b and D-loop are most dominant markers utilized for the hereditary portrayal and for the measurement of the genetic inconstancy in chosen five haplotypes of Pakistani camel breeds. Phylogenetic evaluation indicates that two clades of camel dromedary and bactrian turned out as of particular ancestry and demonstrated distinctive genetic variability between them (Babar *et al.* 2015; Ali *et al.* 2018).

Genetic Studies on Coat Color Relevance with Milk Productivity

Earlier Nigerian pastoralists believe that the coat color is related with milk production and season. Accordingly, they used to relate dromedaries of dark-brown color with high milk yield and in particular they thought that sand-brown camels produced more milk in dry season. On the other hand, they considered grey-white camels good for aesthetic value but are poor in milk production during dry seasons but produces considerably greater amount of milk during rainy season. To further explore this correlation several studies have been conducted on the subject matter whether there is any significant association between coat color and milk production (Mohammed 2000; Kugonza *et al*. 2012).

Camel Adaptability and Production Potential

Impacts of climatic changes are not restricted to selected areas of life but it is affecting directly or indirectly agriculture, economics, environment, livestock, culture etc. Increase in human population is mounting pressure on the production systems of livestock to meet daily lively demands which is impossible without the exploitation of wide variety of sources. Under such circumstances camel is a significant contributor to food security challenges providing an ample amounts of meat and milk (Tariq *et al.* 2014). Camel has an edge in this scenario because of its adaptation to successful survival in arid and semi-arid regions maintaining multidimensional productions at the same time (Al-Jassim and Sejian 2015). Such unique features of camels demand comprehensive exploration of their physiological responses for comprehensive understanding of its inherent potential and its superiority over other livestock (Tomanek 2010). One clue to this unique adaptation lies in the presence of a group of proteins, called heat shock proteins (HSP). These proteins are involved infolding, translation and finally they move across the membranes of camels under r stressful and/or no stressful environmental conditions (Pastukhov *et al.* 2005). HSPs function as a defense strategy against thermal stress in camels. A few degree rise in temperature stimulates the synthesis of HSPs which enhances the adaptive capability of camels (Sadder *et al.* 2015). Additionally, these molecular chaperones incorporate proteins between cell compartments, consume flimsy and dis-collapsed proteins. Furthermore they also help in disintegration of protein buildings, collapsing and refolding of proteins with final control of administrative proteins (Daugaard *et al*. 2007).

The presence of Y-shaped antibodies, consisting of two long and two short chains, impart camels a well-developed immune system which plays a pivotal role in attaining their excellent adaptability against hostile desert environment. Contrary to above some anti-bodies have only two long chains. It has been observed that presence of small antibodies small antibodies enhances the durability and potency of the immune system (Raj *et al.* 2018). Moreover, production of small quantity and highly concentrated urine conservatively uses water for excretion of metabolic wastes another adaptation in desert life (Al-Jassim and Sejian 2015). Hump of camel which is actually a fatty tissue is another addition which serves as an insulator. This physiological adaptation helps camels to travel long distances even up to 160 km without any water requirements still surviving successfully under hostile living environment (Chase 2019). Parts of its adaptations comes from the presence of oval shaped RBCs compared to circle shaped in other livestock which in which facilitates free movement of RBCs during dehydration withstanding and makes them much better to withstand high osmotic variation with minimum damages without taking in any additional water consignments (Hoter *et al.* 2019). Such organismic physiological adaptations support camels to successfully tolerate intrinsic thermal and hydrological fluctuations. Water is also conserved in camel body when it breathes air out because water vapors are entrapped in its nose and are re-inhaled in the body. Intake of green fodder adds sufficient moisture to camel body keeping them hydrated (Marai *et al.* 2009). Camel kidneys and digestive system is quite efficient in absorption of maximum water producing concentrated urine and dry feces. Contrary to other drought resilient species of the world, camel can live without water up to a week. In developing and climate change stricken countries, camel can serve as a multipurpose livestock animal with least expenditure and lots of benefits (Ayoub and Saleh 1998; Al-Jassim and Sejian 2015).

Camel Milk Productivity

Productivity of any animal principally depends on its production and rates, types of breeds, associated with some other biological and physiological factors. Such factors help camels in amelioration of its production potential and sustainability under stressful environment (Farrag *et al*. 2019).

Camel has always been a source of livelihood for the nomads. They have been and are dependent on camels for food and shelter because of insecurity of food in their living desert environment. Such environmental conditions prevail in African countries like Sudan, Somalia, Ethiopia and Djibouti which therefore have maintained almost 18 million of camel population to support their livelihood. This number individuals is quite significant if we compare it to 28million total camels present now at global level (Lund 2019). If we talk about Pakistan FAOSTAT (2015) Economic survey (2013-2015), shows that one million dromedary camels are distributed in various regions of Pakistan (Nagy and Juhasz 2016).

Chemical Composition of Camel Milk

One of the rough cost estimates shows that during the last 50 years, non-cattle milk demand has almost been doubled. Under these circumstances camel milk is highly reliable and potential alternate source. There is variety of camel breeds mainly distributed in the Middle-East, Africa and Asia with varying population levels. These breeds have been genetically improved by crossbreeding with milk producing varieties to enhance overall milk yield per individual (Nagy *et al*. 2013). Breed differences contribute to the quality of milk they produce. For example milk from bactrian camel has 6.67% fat, 3.33% protein and 2.77% lactose while dromedary camel milk has 5.94% fat, 3.03% protein and 3.12% lactose (Konuspayeva *et al*. 2009). Fats in the camel milk are finely homogenized with high level of water. Camel milk is rich in unsaturated fatty acids like linoleic acid, with excessive amounts of vitamins like B complex, E & A, and minerals like Co, Na, Mg, Ca, Mn, Fe, P, K, Zn (Al haj and Al Kanhal 2010; Abou-Soliman *et al*. 2017). Other than breed differences composition of camel milk also varies with topographical and existing natural conditions where the camels are inhabiting. Hence camel is efficient enough to produce milk under hot and dry season with varying chemical composition (Aujla *et al*. 1998). Average milk production of camel is 15-20 liters/day while some good breeds can produce up to 35 liters of milk/day (Mal and Pathak 2010).

Replacement of Mother's Milk

Though mother's milk is the best and first source of balanced nutrition for an infant but sometimes maternal reasons infants to get his/her food requirements growth and survival which forces to search for some alternatives. Under these conditions camel milk has proved itself a possible and dependable alternative to human milk. Low casein and high protein contents with comparatively better digestion and absorption of camel milk make it most suitable substitute for human milk (Berhe *et al*. 2017). Saturated fats are in higher concentrations as compared to unsaturated fats (El-Agamy *et al*. 2009). Vitamin B2, B1, C and niacin are higher while b1?? is in lower amount in camel milk (Qureshi 1986). Total solids (TS) are 1.23 times higher with higher fat and ash contents than that of human milk. Major mineral contents (K, Cl, P, Ca and Na) however did not differ from each other though difference are quite obvious in their quantities which are comparatively higher in camel milk. For example concentration of Calcium (Ca), Potassium (K) and Chlorine (Cl) is 3.2, 2.9, 2.1 times higher than human milk but Zinc (Zn) is in lesser amount (Shamsia 2009). Immuno-globulins are in high amount in camel milk than human milk but lysozyme and lactoferrins are comparatively in quantity (Yaqoob and Nawaz 2007). Some essential and non-essential amino acids like Lysine, Threonine, Glycine, Valine and Glutamic acid are common in human and camel milk.

Comparison of Camel Milk with other Ruminants

Physiochemical properties of camel milk are similar to that of human, mare, donkey and other ruminants. Despite several similarities camel milk still possess some unique biological and physiological features which make camel milk superior to other livestock. When compared animal itself to other livestock inherently it possess some distinct qualities like retention of water in the body for a longer period of time in desert life which make it superior to other livestock (El-Agamy 2007). This peculiar quality of camel differs from other livestock in essence that other animals maintain homeostasis by cooling their body by perspiration but camel body does it with its water storage capability for elongated period of time. Camel lowers its body temperature at night and conserves body heat during the day time so it does not require the evaporation for maintaining the body temperature. Though goat and camel, have same body temperature but unlike goats under heat stress this circadian rhythm of core body temperature is delayed in camel. This helps to maintain its homeostasis even under unfavorable climatic conditions hence this physiological adjustment mechanism increases the survival opportunities of camel compared to goat (Park and Haenlein 2008). Talking about its feeding behavior camels can conveniently feed on shrubs, herbs and different types of weeds to meet its dietary and water requirements while other livestock cannot do that (Gauthier-Pilters 1979). Camels wander about in arid and semi-arid regions, feed on halophytes and meet its salt requirement which is an important contributor to its health. Compared to dietary habits of camel other livestock cannot achieve such an exhaustive feeding nor can graze on halophytes. If we consider feed conversion ratio camel is more efficient in converting feed in to milk yield. For example a cow requires 9.1 kg of feed but camel needs only 1.9 kg to produce the same amount of milk (Stephenson *et al*. 1980). The lactalbumin antioxidant activity of camel is greater than bovine because of higher amino acid residues (Singh *et al*. 2017). Sheep and camel have same blood chemistry and body temperature but their capability to resist harsh climate is completely different. Higher concentrations of lactoferrin and lysozyme are present in camel milk as compared to bovine milk. Ascorbic acid concentration is three times higher in camel milk than any other mammalian milk (Abdalla 2014). Vitamin C is 30 mg/L in camel milk that is much higher as compared to goat (10.7 mg/L) and cow (20 mg/L) (Bouhaddaoui *et al*. 2019). Comparison of chemical composition of camel milk with other ruminants is given in Table 3.

Anti-diabetic Property of Camel Milk

Around the world 370 million people are diabetic. Diabetes Mellitus is the result of an endocrinal disorder which reduces the required quantity of insulin production and its availability in blood for efficient utilization of blood sugar. Individual

Table 3: Comparison of Camel milk with other ruminant's milk

Species	Water%	Lactose%	Protein %	Fat%	Ash%	References
Camel	81.4-87	4.4	3.1	3.5	0.8	(Ereifej *et al*. 2011)
Human	88-89	7.0	1.0	3.8	0.2	(Mosca and Giannì 2017)
Cow	77-91	12.8	3.2-3.8	3.7-4.4	0.7-0.8	(Samková *et al*. 2012)
Sheep	75-87	13-25	5.6-6.7	6.9-8.6	0.9-0.1	(Park *et al*. 2007)
Goat	84-88	4.6	3.1	3.5	0.79	(Raynal-Ljutovac *et al*. 2008)
Buffalo	82-84	4.9	3.8	7.6	0.78	(Han *et al*. 2007)

becomes hyperglycemic with consequent changes in carbohydrate, fat and protein and protein metabolites in the blood (Korish *et al*. 2020). Various biochemical studies have revealed that camel milk contains insulin, lactoferrin and immunoglobulin which makes camel milk anti-diabetic (Aqib *et al*. 2019; Izadi *et al*. 2019; Agrawal *et al*. 2020). Additionally epidemiological reviews demonstrate that low incidence of diabetes in camel milk consuming population has the better tendency to manipulate blood sugar levels. Level of insulin in camel milk has been observed up to 150 U/mL (Kula 2016).

Camel insulin differs from human by four amino acids and from bovine and buffalo just by one amino acid but none of these amino acids influence explicitly toward digestive enzymes (Shareha *et al*. 2017). Camel insulin is shielded from proteolysis in the upper gastrointestinal tract and is epitomized in nanoparticles that encourage its ingestion and easy absorption to the circulatory system. On the other hand camel milk insulin would not make coagulum in the acidic condition of the stomach, like insulin present in other different mammals (Al-Alawi and Laleye 2008). It is evident that the half cysteine rich protein affects receptor conformation and as an activator of intracellular signaling process, makes it anti-diabetic with safe and efficient glycemic control (Eglen and Reisine 2011).

Anti-microbial Effect

Camel milk acts as an antimicrobial agent because of the presence of lactoferrin, lysozyme, lactoperoxidase and immunoglobulin in it (EL-Fakharany *et al*. 2012). Various studies have shown that that immunoglobulins present in camel milk have neutralizing potential against tetanus toxin and other viral diseases like Foot and Mouth disease and rotaviruses while lactoferrin present in camel milk act both as has dual effect as bacteriostatic & bactericidal agent. In this way it can improve immune system of the animal inhibiting excessive microbial growth in the body. Lactoferrinin present in camel milk are in higher amounts as compared to any ruminant milk (Redwan *et al*. 2016). Lactoperoxidase present in camel milk on the other hand shows bactericidal effect on gram negative bacteria, inhibits its undesirable growth and stimulates host defense system in an animal (Badr *et al*. 2017). Different studies were conducted over the antimicrobial effect of camel milk which have revealed that camel milk can be used against various kinds of gram-positive and gram-negative bacteria such as *Listeria monocytogenes*, *E.coli*, *Staphylococcus aureus* and *Salmonella typhismurium* (Benkerroum *et al*. 2004; Kula and Tegegne 2016).

Camel Milk as a Therapy against Crohn's and Autism Disease

Peptidoglycan Recognition Proteins (PGRP) are present in excess amount in camel milk. Crohn's infection is irritation of the digestive tract that aggravates with autoimmune disease. *Mycobacterium avium* contamination causes Crohn's ailment (Gizachew *et al*. 2014). Bactericidal properties of camel milk combined with PGRP with healing response associated with immunoglobulin showed viable treatment of Crohn's sicknesses (Reuven 2013). Autism is an extreme neurodevelopment disorder with physical and social weaknesses of mental hindrance. It happens when chemical balance disrupts which in turn builds oxidative pressure resulting in neurological infections. This development of oxidative pressure ensues when responsive oxygen species (ROS) level crosses the cancer prevention agent of a cell (Al-Ayadhi and Elamin 2013). Camel milk contains immunoglobulins which boosts immunity to aid in mental health (Gul *et al*. 2015). Camel milk assumes a significant job in lessening oxidative stress by adjustment of enzymatic or non-enzymatic cancer prevention agents (Al-Hashem 2009). Camel milk currently possess a rising remedial potential against mental imbalance hence if kids consume its milk it restores chemical balance in the brain following recovery of their mental health (Ghazzawi 2020).

Treatment of Allergies

Dairy milk possesses two allergy causing proteins while camel milk does not. Due to absence of these proteins in camel milk it cannot cause sensitivities to consumers like that of dairy milk. The reason behind these allergies dairy milk is the presence of positive immunological cross-reaction with their counterparts. Camel milk is exception and lacks allergens (Ehlayel *et al*. 2011) like beta-lactoglobulin and a different beta-casein in it. Because camel milk is similar to human milk and contains less sensitive proteins or not at all when compared with bovine milk hence it is considered a good alternative and safe dietary for kids (Shabo *et al*. 2005). With mitigation of allergic reactions, it also reinforces the immune system of kids providing them defense for the future. Apparently camel milk has quick, positive and durable impact in youngsters with minimum nutritional sensitivities (El-Agamy *et al*. 2009).

Potential of Camel Milk against Cancer and Tumor

Immunoglobulins called IgM, IgG, IgA and IgD present in camel milk affects immunity exclusively and quite differently from other agents. Traditional medications used for immunity suppress the activity of immune system instead of combating the diseases. Camel milk however strengthens the immune system of an organism indirectly control the diseases. Like other antibodies immunoglobulin subclasses IgG2 and IgG3 just have two heavy chains, their small size make them more dynamic and efficient in controlling antigens (Korashy *et al*. 2012). Lactoferrin of camel milk is strong enough to restrain the multiplication of malignant cell growth up to 56% and capable enough to fix DNA damage (Habib *et al*. 2013). Camel milk prompts apoptosis in HepG2 and MCF7 (human breast) cell expansion through apoptotic and oxidative-stress-interceded mechanisms (Yang *et al*. 2019). Enzymatic absorbability and cancer prevention capability of camel milk is because of α-lactalbumin which shows high level of hydrolysis with both trypsin and chymotrypsin protein. On digestion, camel milk creates peptides which possesses antioxidant ability (Alebie *et al*. 2017; Uversky *et al*. 2017). Camel milk casein peptides shows higher cancer prevention capability hence giving it the restorative properties, the characteristics not present in dairy milk (Homayouni-Tabrizi *et al*. 2017). Camel milk has both cytotoxic effects and hostility to angiogenic activity against malignant growth of cells. In this way it can fix tumors as exceptionally dynamic antibodies tie and afterward execute the tumors in hepatocellular carcinoma, colon carcinoma, lung disease and leukemic cells. Its potential thrombolytic activity restrains the coagulation and fibrin development which results in decreased development of metastatic tumor cells (Alebie *et al*. 2017).

Skin Health and Anti-aging

Utilization of camel milk and its breakdown in its constituents produces peptides that are characteristically cancer preventing agents and ACE-inhibitors. Vitamin C in camel milk reinforces body cells, resists promoter, and serves as defender to collagen and tissue fixation (Mehta and Agrawal 2020). Presence of α-hydroxyl acids in camel milk diminishes skin wrinkles, age spots and finally skin dryness (Yadav *et al*. 2015). Liposomes in camel milk has potential to restore fixing ability and consequently act antagonistically for maturing impact (Chen *et al*. 2017). The milk contains lanolin, vitamin B, C, carotene and iron which smoothens the skin, restores it in its original condition ultimately assisting in the treatment of skin ailments like dermatitis, acne, Psoriasis and Eczema (Ali *et al*. 2019).

Treatment of Hepatitis and Tuberculosis

Ascorbic acid and fats in camel milk improve liver function. Lactoferrin present in camel milk acts as a strong inhibitor against hepatitis C virus (El-Fakharany *et al*. 2017; Ameen and Hameed 2019). Continuous intake of camel milk has cured different human diseases like tuberculosis, empyema, chronic pulmonary and multiple drug-resistant diseases (MDR) (Yadav *et al*. 2015; Ameen and Hameed 2019).

Conclusion

The potential of camels as a food producer in the arid and semi-arid areas of the world should be further explored, and improved. The absence of reliable genetic strategies for improvement of its genetic potential is a real handicap for camel development at commercial scale. A plan of action be proposed and further strategies can be devised considering its breeding component. This component is a leading theme and can generate useful information from the close association of breeders and farmers. This newly generated information can serve as a framework for extension programs for camel farming with multidisciplinary involvement at a larger scale. In order for the camel industry to benefit from science, dynamic mechanisms should be established to bring together livestock scientists working in arid and semi-arid areas to facilitate exchange of findings, avoid redundancy and set up research priorities relevant to local animal breeds in general and camels in particular. Camel has no match with other livestock in terms of survival, feed and performance under all climatic conditions irrespective of their nature. Fast changing global scenario demands to recognize the potential of this incredible creature and utilize its capabilities to combat the adverse climatic conditions and ensure food security of inhabitants present in that particular area. Climatic changes are affecting all kinds of food producing systems, directly or indirectly. Shortage of grazing land, global warming, and insufficient water resources both qualitatively and quantitatively are becoming a limiting factor for food production. Drought, floods, heat waves, cyclones, wild fires are those factors which are further worsening the productive capability of the biosphere. Camel has the potential to cope up with the deteriorating condition of the environment and upgrading the economy of a country as well. It can provide meat, milk, medicine, and transportation to its owners and well-wishers. Compared to other dairy milk camel's milk is called white gold for its peculiar features resembling to human milk. Milk of camel is unique due to its antioxidant, antibacterial, antiviral, antifungal, anti-diabetic, anti-allergic and anti-tumor qualities. Due to adverse climatic conditions camel raising and its further promotion is the best option to adopt because it can successfully survive in such harsh conditions which are not far from all the ecosystems of the world.

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