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Review Article

MAJOR MILK BORNE MICROBIAL DISEASES OF CAMELS

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ABSTRACT

Camel is an important livestock particularly in the pastoral community because of its extraordinary ability to perform in arid and semi-arid environments. Camel plays a central role in the livelihood of pastoralists by providing the milk, meat and draught power. However, milk can also serve as a vehicle for many organisms. Brucellosis, tuberculosis and streptococcosis are the major camel diseases transmitted through the consumption of the contaminated milk. Milk borne zoonoses can occur in sporadic or epidemic form resulting into high morbidity and mortality. The habit of drinking raw milk in pastoral areas is the main predisposing factor for acquiring milk borne zoonotic infections. Continuous awareness of the people in pastoral regions by imparting health education about the source of infection, mode of transmission, nature of disease and preventive measures such as boiling of milk before consumption, personal hygiene etc. would certainly help to reduce the incidence of milk borne zoonoses. In addition, the surveillance of the important camel zoonoses is emphasized in order to frame the strategies for their control.

Key words: Camel, milk, pastoralists, zoonotic diseases

Livestock plays a pivotal role in the well-being of human beings. Camel is a sturdy animal with a great potential to survive in hard environmental conditions. It produces milk, meat, leather, wool and hair and also serves as riding, pack and drought animal (Dioli and Schwartz, 1992). However, like other domesticated animals, camels are also susceptible to many infectious diseases caused by various microbes which include viruses, bacteria, fungi and parasites. Some of the camel diseases are zoonotic in nature (Pal, 2007).

CAMEL PRODUCTION

The camels were domesticated about 4000 years ago in southern Arabian Peninsula, probably the areas of Yemen and Oman and subsequently distributed to the rest of the world (Wilson, 1998). It is the most important animal in the arid area of Africa particularly in Eastern Africa i.e. Somalia, Sudan, Ethiopia, Kenya and Djibouti. Approximately, 11.5 million camels in this region represent over 80% of the African and two thirds of the world's camel population (Dioli and Schwartz, 1992). However, some dromedary keeping countries are located outside the tropics in North and South America, Western Asia, India, Candy islands, Caribbean, Italy and Southern Spain (Knoess, 1977). The ability of camel to adapt to extreme aridity of the habitat is unique amongst large herbivores. The most significant aspect of this adaptation is the economic use of water. At high environmental temperature, up to 80% of the total daily water loss may be accounted by heat dissipation through evaporative cooling and 95% of heat losses in camels are achieved by sweating (Dioli and Schwartz, 1992).

In many areas, camels are the main source of milk for subsistence and contribute more to the total milk supply from all species in the dry than the wet season (Wilson, 1998). Many traditional owners keep camels only for milk production and it is the most appreciated and valuable product produced by the nomads. The main value of camels as milk animal, however, is important at least for traditional owners due to its ability to give milk over long periods and also in dry seasons (Mohammed, 1987; Wilson, 1998).

CAMEL MILK AND ITS COMPOSITION

Milk is the first natural food of all young mammals immediately after birth. Because of its high nutritional value, milk is considered as “the most nearly perfect food” as it provides more essential nutrients in significant amount than any other single food (Etzion and Yagil, 1980; Pal, 2012). The composition of camel milk is similar to that of the goat but it contains more lactose. Casein is lower in the camel's milk than in the cow's milk. It is usually bluish white in color and may have slightly salty taste and slightly acid or sharp taste because the pH is about 6.5. Camel milk is thinner than cow or buffalo milk. It contains higher water, sodium, potassium, phosphate and chloride contents whereas, low calcium and magnesium contents. It is also a good source of vitamin C. The content of vitamins of the B-complex is comparable to that of other domesticated

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animals (Farah, 1993; Wilson, 1998). The variability of camel milk composition depends on the geographical location, physiological stage, feeding condition, milk production genetic and health status (Khan and Iqbal, 2001). Camel milk has high antimicrobial activity to inhibit the growth of pathogenic microorganisms when compared with cow's milk (Kosparkove, 1975; El-Agamy *et al.*, 1992). For many years, it was thought that the composition of camel milk made it difficult or impossible to convert liquid milk to butter and cheese. Traditional products such as milk fermented to become "Susa" (a type of sour milk) are not difficult to make and are highly appreciated (Wilson, 1998). The relatively higher concentration of vitamin C in camel's milk aids to an improvement of liver function. Camel milk is used to treat jaundice, malaria, constipation, tuberculosis, HIV, cirrhosis of the liver, rickets, asthma, anaemia etc. (Kosparkove, 1975; El-Agamy *et al.*, 1992; Farah, 1996).

MILK BORNE ZOONOSES

Microorganisms in milk are always a consequence of contamination. Thus, the bacteria in milk fall into two groups; those that are present in the tissues of an infected camel and find their way into the udder; and those which enter the milk usually from sources external to the animal (Acha and Szyfers, 2001). Tuberculosis, brucellosis and streptococcosis are important microbial zoonoses as they affect camels and are also transmissible to human beings through raw milk consumption (Pal, 2007). Therefore, the objective of this review is to briefly discuss these infections.

Brucellosis: Brucellosis is a highly infectious re-emerging bacterial anthropozoonoses of worldwide significance (Hadush and Pal, 2013). Disease is recorded in many species of animals including camel (Pal, 2007). The disease in camel is caused by *Brucella abortus*, *B. ovis* and *B. melitensis*. *B. ovis* and *B. melitensis* infections in camel appear to be connected with infection of sheep and goats that are widely kept together. Brucellosis eradication campaign in the Eastern region of the UAE during a five year period revealed 5.8% reactors in 1991 and 0.01% in 1996. Since no camels have been culled due to brucellosis, it is believed that there was reduction in brucellosis in sheep and goats (Moustafa *et al.*, 1998). Gumi *et al.* (2013) conducted a cross-sectional study to assess seroprevalence of *Brucella* in pastoral livestock in southeast Ethiopia, in three livestock species (cattle, camels and goats) during July 2008 to August 2010. Sera from a total of 1830 animals (862 cattle, 458 camels and 510 goats) were screened and a few were found positive for *Brucella* spp.

Megersa *et al.* (2012) collected sera from 575 cattle, 1073 camels and 1248 goats in the Borana pastoral system of Ethiopia between December 2007 and October 2008. A total of 8·0%, 1·8% and 1·6% cattle, camels and goats, respectively, had antibodies to *Brucella* antigen. Positive reactors were found in 93·8% of the villages. Increase in household-level species composition and wet season were found to be risk factors for seropositivity in camels and goats, respectively. Existence of more than one sero-reactor animal species in most villages and association of increased livestock species composition with seropositivity may lead to the possibility of cross-species transmission of *Brucella* infections. Mentaberre *et al.* (2013) conducted a study on dromedary camel population in the Canary Islands (main export point of dromedaries to continental Europe and Latin America). Of the 100 Canarian camel sera tested for the presence of antibodies against *Brucella* sp., 1% cases had antibodies. The presence of antibodies warrants implementation of adequate control measures.

B. melitensis is wide spread in Africa and the Middle East and *B. abortus* is wide spread in the former USSR. Mixed infections with various *Brucella* species in the bacterian camels in Russia are also reported (Solonitsyn, 1999). The incidence of brucellosis in camel populations appears to be related to the breeding and husbandry practices (Richard, 1980). The infection rate in some regions of the former USSR, where camels are kept on large farms is 15% (Palgov and Zhulobovski, 1964). Richard (1980) reported the prevalence of 5.5% in countries with more extensive forms of husbandry such as Sudan.

Brucella infection in domestic animals may cause stillborn calves, retained placenta and reduced milk yield (Pal, 2007). Retained placentas have not been described in camels. This may be a result of the difference in the placental attachments (Fowler, 1998). *B. abortus* and *B. melitensis* have been isolated from milk, vaginal swabs, aborted fetuses, lymph nodes and hygromas of infected camels from different countries (Richard, 1980). In Ethiopia, brucellosis is known to be present in livestock of intensive dairy farms located in the vicinity of Addis Ababa, however, its presence in camels in different camel rearing areas had also been reported (Teshome *et al.*, 2003). Bekele *et al.* (2013) conducted sero-epidemiological studies on camel brucellosis in the Afar region of Ethiopia. In this study 461 camels were tested and 120 livestock owners were interviewed. The modified Rose Bengal plate test (mRBPT) and complement fixation test (CFT) were used as screening and confirmatory tests, respectively.

In the camel herds tested, 5.4% had antibodies against *Brucella* species, and the district level seroprevalence ranged from 11.7% to 15.5% in camels. The logistic regression model for camels in a herd size > 20 animals (and greater than four years of age showed a higher risk of infection when compared to small herds and those ≤4 years old. The questionnaire survey revealed that most respondents did not know about the transmission of zoonotic diseases, and that their practices could potentially facilitate the transmission of zoonotic pathogens.

The potential public health hazard of camel brucellosis is due to *B. melitensis* and *B. abortus*, which were isolated from milk and other samples of camel origin (Agab *et al.*, 1994; Walker, 1999; Shimol *et al.*, 2012). Shimol *et al.* (2012) investigated an outbreak of acute brucellosis in Israel in which 15 persons who consumed camel milk developed fever and arthralgia. Sixty percent of cases had serum agglutination test titers of 1:160 or higher and 4/8 (50%) had positive blood culture for *B. melitensis*. Blood and milk serology and milk culture taken from the female camel were positive for *B. melitensis*. Abattoir workers, butchers, dairymen, livestock handlers and veterinarians are also at risk to acquire brucellosis (Seifert, 1996; Acha and Szyfres, 2001; Pal *et al.*, 2013).

The clinical diagnosis of brucellosis is difficult; therefore, it is advisable to perform laboratory tests. The diagnostic methods available for detecting brucellosis are microbiological, immunological and molecular types (Quinn *et al.*, 2004; Pal, 2007; Hadush and Pal, 2013). A wide range of serological tests such as *Brucella* milk ring test, Rose Bengal plate test (RBPT), serum agglutination test (SAT), complement fixation test (CFT), enzyme-linked immune sorbent assay (ELISA) and others are used to diagnose brucellosis (Pal, 2007). PCR technique has been employed to detect *Brucella* in milk of infected cattle, goats, sheep and camels (Hamdy and Amin, 2002; Pal, 2007). Khamesipour *et al.* (2015) reported a TaqMan real time PCR assay to detect *Brucella* spp. in camels. These authors detected *Brucella* in apparent healthy camels slaughtered at an abattoir in Iran. Use of serological surveillance and removal of infected animals is important. Segregation of parturient females will reduce contamination of the environments.

Tuberculosis: Tuberculosis is a major international public health problem, which affects humans as well as wide variety of animals including camels (Acha and Szyfres, 2001; Pal, 2007; Pal *et al.*, 2014). *M. tuberculosis*, *M. bovis* and atypical mycobacteria such as *M. kanasii*, *M. aquae*, *M. aquaevarureolyticum*, *M. fortuitum* and *M. smegmayis* have been isolated form dromedaries (Elmossalami *et al.*, 1991; Kinne *et al.*, 2006). There are different modes of spread of tuberculosis between camel herds (Bush *et al.*, 1990). It is believed that camels suffering from pulmonary tuberculosis infect healthy animals via aerosols.

In Ethiopia, the camel tuberculosis is prevalent in pastoral regions. The identification of its causative agents is important to encourage the efforts for its control and reduce its risk of zoonoses to the pastoralist community (Mamo *et al.*, 2011) as milk and milk products are consumed raw (Seifert, 1996). The widespread outbreaks of *M. tuberculosis* are of considerable concern to public health officials, conservation agencies and veterinarians responsible for health status of animals in zoos, animal parks and private herds. Donchenko *et al.* (1975) isolated *M. tuberculosis* strains from 46 pooled camel milk samples from 712 lactating camels in Russia. Tuberculin test was performed in these herds and 9.1% animals were found reactive. The circus and zoo camels with active disease also present danger to man (Panebianco, 1977).

There is very little information on the prevalence of the human tuberculosis caused by *M. bovis* in developing countries. Information on the prevalence and distribution of bovine tuberculosis in Africa is scarce; however, the available reports indicate that number of countries including Morocco, Egypt, Ethiopia, Uganda, Tanzania, Zambia and Malawi are areas with exceptionally high level of infection (Daborn *et al.*, 1996; Girmay *et al.*, 2012). Mentaberre *et al.* (2013) conducted a study on dromedary camel population in the Canary Islands and tested 100 camel sera for the presence of antibodies against *Mycobacterium* sps. Antibodies against *M. avium paratuberculosis* and *M. tuberculosis* complex were detected in 22% and 10% cases. Strict preventive and control measures are thus required to avoid a potential dissemination of infection to other territories.

With increasing HIV infection in Ethiopia and the practice of consumption of raw animal products by most Ethiopian population, there is a potential risk of zoonoses of *M. bovis* in humans. In the rural areas of Ethiopia, practice of drinking raw milk and very close contact with animals (sharing shelter at night) can intensify the risk of transmission and spread of *M. bovis* (Kidane *et al.*, 2002). Pal *et al.* (2014) reviewed the growing significance of *M. bovis* in human health.

Strict safety precautions must be enforced when working with specimens suspected of containing *M. bovis* or *M. tuberculosis*. All procedures must be carried out with in a biological safety cabinet housed in

a separate room (Quinn *et al.*, 2004). Molecular techniques such as RFLP (Restriction fragment length polymorphism; good for *M. tuberculosis* but not good for *M. bovis*), VNTR (variable number tandem repeat) and deletion typing are used currently. A nested molecular amplification detection assay is both fast and sensitive (Dinnes *et al.*, 2007).

Intradermal skin testing, which is the classical diagnostic test, often gives non-specific reactions in camels. One of the reasons for the non- specific reaction is that the skin of the neck is very thick and resilient, which makes accurate measurement very difficult (Simmons, 1989). It is suggested that the base of the pinna may be the most suitable location for tuberculin testing. However, it is recommended that several tests should be used to aid in the diagnosis of tuberculosis in camels (Fowler, 1998).

Gumi *et al.* (2012) tested 1,418 animals (421 cattle, 479 camels and 518 goats) belonging to 94 herds for bovine tuberculosis (BTB) by the intradermal tuberculin test in the Somali region in southeast Ethiopia from January to August 2009. The prevalence was 2.0%, 0.4% and 0.2% in cattle, camels and goats, respectively. Prevalence of avian mycobacterium purified protein derivative (PPD) reactors in cattle, camels, and goats was 0.7%, 10.0% and 1.9%, respectively. The high proportion of camel reactors to avian PPD may have an impact on camel production.

Test and slaughter is the most efficient and practical method for the control of bovine tuberculosis in developed countries (test and segregation for developing countries). Tuberculin test every 3 to 6 months have to ensure that any newly infected animal can be eliminated immediately from the disease free herd. Consumption of raw milk should be avoided.

Streptococcosis: It is bacterial zoonoses, which cause disease in humans and animals (Pal, 2007). Inflammation of the udder occurs less frequently in the camels than in other domesticated animals (Ramadan *et al.*, 1987; Fowler, 1998). There might be several reasons why mastitis is uncommon in camels. Each teat has two streak canals that enter into separate teat and gland cisterns. Each teat is associated with a non-communicating double gland. The streak canals are very narrow. This twin duct anatomy with its narrow streak canals might in some way protect against infections. Milking camels are often fitted with udder covers. These covers might reduce injuries to the teats and the udder is protected against gross contamination. However, the more likely explanation why udder infections in camels are less frequent lies in the milk itself. Several substances are found in the milk that inhibits the growth of pathogenic bacteria (Barbour *et al.*, 1985; El-Agamy *et al.*, 1992; Farah, 1996).

Reports of inflammation of camels udder have appeared from various countries such as Egypt (Moustafa *et al.*, 1987), India (Kapur *et al.*, 1982), Saudi Arabia (Barbour *et al.*, 1985), Somalia (Fowler, 1998), Sudan (Obied, 1983) and UAE (Quandil and Ouadar, 1984). Per-acute, sub-acute and gangrenous mastitis with lymph node enlargement have been described in the camel. In acute cases, the mammary secretions are watery, yellowish or blood tinged (Anouassi and Tibaray, 1997). In chronic unilateral mastitis, lactiferous ducts are blocked by accumulation of keratin, and reduced the milk production (Ramadan *et al.*, 1987).

Streptococcus species Lancefield group A (*S. pyogenes*), B (*S. agalactiae*), D (*S. bovis*), R, G, H, L and M are implicated in a wide variety of clinical disorders in humans (Pal, 2007). They have a marked tendency to occur in mixed and secondary infections with other pathogenic bacteria often *Staphylococcus*. The pathogenesis of these bacteria is accounted for to a considerable degree by the soluble toxic substances they produce (William, 1995).

In infection caused by group B streptococci (*S. agalactiae*) two clinical syndromes are distinguished, depending on the age of the infants at the onset of the disease. The acute or early onset syndrome is characterized by sepsis and respiratory difficulties. The delayed onset syndrome generally is characterized by meningitis with or without sepsis. Affected children show lethargy, convulsions and anorexia. Mortality is high in both forms. Infection caused by group A (*S. pyogenes*) is common in man with an apparently higher prevalence in temperate climate. This agent frequently causes epidemics of septic sore throat and scarlet fever. It also causes puerperal fever, pneumonia, tonsillitis, pharyngitis, septicemia etc. (Acha and Szfres, 2001; Pal, 2007).

Smears from pus, exudates or centrifuged deposits of milk can be fixed and stained by Gram's method. Most streptococci produce small colonies and in the case of the beta hemolytic streptococci, the colonies appear translucent. Various biochemical tests are available for presumptive identification of *Streptococcus* species (Quinn *et al.*, 2004). Prevention of human infection transmitted through milk is achieved primarily by proper pasteurization. Practice personal hygiene and infected persons should not participate in milking or handling of other foods (Pal, 2007). Mastitis treatment should be based on culture and sensitivity and

the treating person must be fully aware of the anatomical particularities of the camel's mammary gland.

Other Zoonotic Infections: Other zoonotic infectious agents include *Staphylococcus aureus*, *Salmonella* species and *Listeria monocytogenes* and Rift Valley fever (Pal, 2007). Staphylococcosis is a bacterial zoonoses and is mainly caused by *S. aureus*. Disease is described in humans and a wide variety of animals including camels (Pal, 2007). The organism is isolated from camels and can be considered a reason for subclinical mastitis in dromedaries. Studies indicate that *S. aureus* is the cause of chronic mastitis in camels (Barbour *et al.*, 1985).

Salmonellosis is an important global food borne zoonoses. It is caused by *Salmonella* species and is responsible for a variety of clinical disorders in humans and in animals (Pal, 2007). *Salmonella* infection in camels has been reported in Ethiopia, Sudan, Egypt, Somalia, USA, UAE; *S. typhimurium* and *S. enteritidis* are more prevalent in camels (Matofari *et al.*, 2007).

Listeriosis, caused by *L. monocytogenes*, is an important emerging food borne zoonoses of global significance (Pal, 2007). Very few reports are available about *Listeria* infections in old world camels (Matofari *et al.*, 2007). Rift Valley fever is an emerging viral zoonoses, which was first described in Rift Valley of Kenya in 1931 (Pal, 2007). The disease has been recorded in humans and several animal species including camel (Pal, 2007; Pal *et al.*, 2012). There are some evidences that humans may also become infected with Rift Valley fever this diseases by ingesting unpasteurized or un-boiled milk of infected animals (WHO, 2007).

CONCLUSIONS

Camel's milk can be contaminated with microorganisms of exogenous and endogenous source. Tuberculosis, brucellosis and streptococcosis are major diseases of public health concern to the pastoral community. Active surveillance for these diseases in camel rearing areas is very important. Strategies to control these diseases in camel have to be designed based on the surveillance results. Participatory control program is very helpful. Creating awareness about the disease in communities will help better understand the disease in animals and may avoid consuming raw milk and milk products. Hygienic practice should be promoted to the camel herders about how to milk, handle, store, and transport camel milk under acceptable standards.

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