Review Article

Advancement in Dairy Science Research

Review on Goat Mastitis and Associated Bacterial Zoonoses in Raw Milk from Mastitis Infected Dairy Goat

Mohammed Bedruddin Aliyi(DVM)*

Department of Veterinary Medicine, Haramaya University, College of Veterinary Medicine, P.O. Box 138, Dire Dawa, Ethiopia

Corresponding Author
Mohammed Bedruddin Aliyi, Department of Veterinary Medicine, Haramaya University, College of Veterinary Medicine, P. O. Box 138, Dire Dawa, Ethiopia.

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Abstract
Goat milk has medicinal value for children and contributes much more for the wellbeing of human baby. Goat milk provides more nutritional value than dairy cow's milk. Despite the large number of goats and their contributions to the livelihood of the farmers, goat productivity is low due to prevalence of different diseases. One of the major diseases that affect the dairy goats is mastitis. Mastitis is an inflammation of the mammary gland, caused by over 150 different contagious or environmental micro-organisms. Mastitis in goats constitutes an enormous animal health problem. In addition to causing health problems, inflammation of the mammary glands can also cause poor quality of milk. Milk produced by goats with mastitis presents a serious risk in terms of public health as it can be linked to milk-borne diseases for humans. Raw milk from Mastitis infected goat is usually colonized by a variety of many zoonotic pathogens such as enterohaemorragic Escherichia coli, Salmonella typhimurium, Listeria monocytogenes and Staphylococcus aureus, Brucella melitensis, Mycobacterium bovis. These pathogens in milk have been linked to mastitis milk. These zoonotic organisms may lead to health problems in the human population such as tuberculosis (TB), brucellosis, haemorrhagic enteritis, salmonellosis and food poisoning. Transmission of pathogens from animals to humans can occur via consumption of milk, especially when these products are consumed raw.

Keywords: Bacteria, Mastitis, Milk, Zoonoses

1. Introduction

Goat production is one of the low resources demanded and efficient farming types, since goats have broad feeding habit, adaptation to unfavorable environmental conditions, low cost of maintenance, inherent suitability for small scale production and their short reproductive cycle. These provide goats with comparative advantage over cattle and sheep to suit the circumstances of especially resource poor livestock keepers [1]. Since goats browse different variety of trees and shrubs, goat owners believed that goat milk has medicinal value for children and contribute much more for the wellbeing of human baby [2].

Milk production in goats is an active and emergent business in harsh climate areas where large ruminants cannot be reared or are difficult to rear and it largely contributes to the mainstream dairy milk production [3]. In addition to this, goat milk provides more nutritional value than dairy cow's milk [4]. Highly milk productive goats are able to produce milk as much as 20 times their body weight [5]. Goat milk is highly nutritious and has a similar nutritional profile to those of human's breast milk [6]. Despite the large number of goats and their contributions to the livelihood of the farmers, goat productivity is low due to prevalence of different diseases and parasites [7]. One of the major diseases that affect the dairy goats is mastitis [8].

Mastitis is an inflammation of the mammary gland, caused by over 150 different contagious or environmental micro-organisms [9]. In lactating dairy goats, the inflammation of the mammary gland is one of the most common infectious diseases [10]. It occurs after several pathogens invades and colonizes the secretory tissue leading to inflammation of the mammary gland [11]. Mastitis in goats constitutes an enormous animal health problem [12].

In addition to causing hygiene and health problems, inflammation of the mammary glands can also cause economic losses due to reduced milk production, poor quality of milk [13]. Mastitis also poses a threat to human health due to the risk of transmitting zoonotic pathogens through ingestion of contaminated milk [14,15]. Milk produced by goats with mastitis presents a serious risk in terms of public health as it can be linked to milk-borne diseases for humans [16]. Though milk is an important food product, milk and milk by-products can harbour a variety of zoonotic pathogens which cause zoonoses [17].

Zoonoses are infections that can spread from animal to man [18]. The World Health Organization (WHO) defines zoonosis as diseases that can be transmitted between humans and animals [19]. Zoonotic pathogens may be bacterium, virus, fungus or other communicable disease agents [20]. These zoonotic pathogens may contaminate milk either whilst the milk is still in the udder [21]. Raw milk is usually colonized by a variety of many zoonotic pathogens such as enterohaemorragic Escherichia coli, Salmonella typhimurium, Listeria monocytogenes and Staphylococcus aureus, Brucella melitensis, Mycobacterium bovis [22]. These pathogens represent an important source of foodborne pathogens [23].

These zoonotic organisms may lead to health problems in the human population such as tuberculosis (TB), brucellosis, hemorrhagic enteritis, salmonellosis and listeriosis [24]. The population that is at higher risk of being infected with this milk borne pathogens includes people who are immunocompromised, the elderly, pregnant women and children [25].

Transmission of pathogens from animals to humans can occur via consumption of milk, especially when these products are consumed raw. Raw milk and products from raw milk containing pathogenic microorganisms can enter the food chain and be responsible for food poisoning episodes among consumers [26]. The transfer of heat-stable toxins produced by mastitis-causing pathogens in milk is another serious potential concern [27]. Pasteurization reduces the number of viable micro-organisms but often does not destroy toxins produced by bacterial pathogens, hence the concern when raw milk is consumed or when pasteurization is faulty [28]. While most milk in developed countries is tested for high SCC and pasteurized before it reaches consumers, in developing countries, milk is often consumed unpasteurized [29]. For this reason, utilization of both raw untreated milk and raw milk cheeses has frequently been associated with foodborne illness [30].

The Objective of this paper is to;

- review the most recent literature about goat mastitis and how intramammary infections in this species affect the milk safety.
- review the public health importance of pathogenic agents involved in the etiology of mastitis.

2. Literature Review

2.1. Mastitis Definition

Mastitis is a parenchymal inflammation of the mammary gland, characterized by physical, chemical, and usually bacteriological changes in milk and pathological changes in glandular tissues [31]. Mastitis cases can be divided on the basis of origin into environmental and contagious [32]. Environmental mastitis is caused by bacterial microorganisms from the surrounding environment, referred to as environmental pathogens, whereas contagious mastitis is due to spread from other infected quarters [33]. Environmental mastitis is caused by microorganisms present in the animals surrounding area. These pathogens infect the udder via the teat canal [34]. The main reservoirs of contagious pathogens are the rectal, rumen, and genital areas in addition to the mammary gland [35]. The infection is spread during milking time when infected milk contacts an uninfected mammary gland and bacteria then penetrate the teat canal [36].

There are many microorganisms that cause mastitis in goats [37]. Unappropriate milking tecniques and unsuitable hygiene conditions increases the infections [38]. Mastitis is a complex disease resulting from the interaction between the agent, animal and the environment, associated with the presence of microorganisms in most cases [39]. It is an important animal health and public health problem, with great economic repercussion in practically every country in the world [40]. A greater number of zoonotic pathogens including brucella (b.) Melitensis, campylobacter spp., escherichia coli, mycobacterium spp., salmonella spp., and staphylococcus aureus were isolated from milk [41]. The prevalence of these pathogens in the milk was associated with the occurrence of diseases in the animals including goat mastitis [42].

2.2. Epidemiology

2.2.1. Geographical Distribution

Mastitis is the most prevalent production disease in dairy herds worldwide [43]. It is a well-documented disease with a heavy burden in both, developed and developing countries [44]. It is a global health problem of lactating animals and it considered one of the most important diseases of domestic animals, caused by several etiologic agents [45].

The study of a disease in a population requires an understanding of the relationships between organisms, hosts and their environment [46]. Moreover, epidemiological investigations include an increase in the understanding of the pathogenesis, maintenance and for infectious agents transmission of disease also when and where a disease may occur to enable the development of suitable control techniques where the delay in epidemiological interference discovery is probably due to the lack of long-term surveys on the incidence of infections as reported [47].

2.2.2. Risk Factors

Environmental risk factors: - Udder disease is affected by a number of external environmental factors (management, manner of milk removal and milking technology, season) [48]. It also including, milking hygiene, management practice, and geographical locality which influence the type and the frequency of isolation of organisms cause mastitis and in particular the routine of machine milking [49,50]. Predisposing factors such as poor management and hygiene, teat injuries and inefficient use of milking machines are known to accelerate the entry of infectious agents and the course of the disease [51]. The high percentage of the subclinical mastitis could be due to a lack of hygiene and to the practice of traditional breeding of extensive type, which favors diseases [16].

Host risk factors: - Internal factors (include physiological status of the body, like stage and order of lactation, oestrus, udder shape, feeding, number of lactation days) are important for the occurrence of mastitis [52]. High stocking density, particularly in intensively managed herds/flocks or during the suckling period, may result in large air concentrations of total microorganisms, coliform bacteria and staphylococci [53]. These effects are probably associated with incorrect ventilation and high relative humidity. The multiplication of various bacteria on the skin (and in the litter) can be subsequently enhanced [54].

Pathogenic Risk Factors: Several pathogens can cause mastitis, Staphylococcus spp. are the most frequently diagnosed causal microorganisms of intramammary infection (IMI) goats and it secretes several toxins contributing to the pathogenesis of mastitis and also plays a role in food borne diseases; even with pasteurized milk because of the thermo-stable enterotoxins [55]. Staphylococcal alpha-hemolysin or alpha-toxin is the most studied and characterized cytotoxin, and is considered a main pathogenicity factor because of its hemolytic, dermonecrotic and neurotoxic effects [56].

2.2.3. Transmission

The group of environmental agents is present in organic matter as soil and feces, in the bed of animals, in water and in the air. The infection occurs mainly in the inter-milking period, but may also occur during milking [57]. Infections by contagious agents occur predominantly during milking, and microorganisms opportunistically invade the mammary gland, causing an immediate inflammatory response [9]. Udder massage and stripping induce air intakes leading to impact [50]. Cluster removal by the milker may also induce impact, since it is often performed without previous vacuum cutting off (the automatic cluster removal is developing) [58]. Bacteria are also transported passively by liners. However, the intra mammary infections (IMI) prevalence's do not seem to be significantly different between dairy (hand or machine milked) and meat flocks [59]. Transmission is also possible by "milk-robber" lambs (buccal carriage) and may be important for staphylococci, Pasteurellaceae, parapoxvirus (contagious ecthyma) [60]. Infection of the udder usually takes place directly through teat canal [61].

2.3. Pathogenesis

The first line of udder defense against pathogens is the teat end. It is open and closed by a sphincter composed of smooth muscles that serves as a barrier to prevent pathogens from entering the canal and prevent milk from escaping [62]. The teat canal is lined with the stratified squamous epithelium, which creates keratin to fill the canal between 30 min and two hours after milking [63]. This time span may vary, creating an opportunity for bacteria near the opening to enter the teat canal [64]. In order to establish the infection, the etiologic agent must surpass the terminal portion of the ceiling, since the integrity of the ceiling is the first line of defense [62]. The bacteria enter the gland through the streak canal and multiply within the udder cells or in the teat duct [11].

The pathogenesis of Staphylococcus aureus mastitis is very complex [66]. It is associated with various surface proteins and virulence factors that are differentially expressed at various phases of the infection [67]. This process entails three key steps, that is adhesion, invasion and evasion [68]. In brief, the first step in the pathogenesis process is adhesion to epithelial cells and extracellular matrix, which permits the bacteria to avoid being flushed out of the udder from milk flux pressure [69]. In the second step of this process, Staphylococcus aureus again expresses different virulence factors to establish infection by invasion into host cells and tissues [70]. The final step in the pathogenetic process is an evasion of the host immune response ((Nesse et al., 2023). Here, S. aureus escapes the host immune response by producing the various virulence factors that helps it not only to evade but also modulate the host immune response in its favor [69]. This mechanism is not only employed by Staphylococcus.aureus but other mastitis causing bacteria such as Streptococcus spp. [71]. Therefore, adherence of microbial agent to teat epithelial tissue permits them to invade or penetrate this protective barrier and migrate to the teat duct [70].

2.4. Clinical Signs

Mastitis is a disease that occurs in several different forms. Generally, in animal, mastitis is divided into clinical and sub-clinical forms [72]. In cases where there are no visible changes in appearance of milk and udder but the milk composition is altered with presence of bacteria accompanied by decreased milk production then subclinical mastitis is diagnosed [73]. Subclinical mastitis is the term used for the inflammation of udder that cannot be detected by clinical methods such as inspection, palpation and organoleptic examination [74]. It is the most important diseases which cause change in the milk composition and any change in its percentage in turn affect the suitability of milk processing and the quality of its products [75].

Clinical mastitis is the term used for inflammation of the mammary gland that are present with obvious symptoms and is characterized by visible abnormalities in the udder or milk of infected animal [76]. Clinical sign in case of clinical mastitis is characterized mainly by appearances of changes in the milk such as flakes and clots and presence of signs of inflammation on the mammary glands such as swelling, heat, pain, and edema [77]. Systemic signs on the animal infected with clinical mastitis including fever, rapid pulse, appetite loss, dehydration, and depression [78].

2.5. Diagnosis

Diagnostic procedures used in mastitis include clinical examination, bacteriological tests, cytological examination of milk (direct by using fluoro-optoelectronic counters and microscopic cell counting, indirect by using the California Mastitis Test or the White Side Test), measurement of milk electrical conductivity and imaging techniques (ultrasonography, endoscopy, infrared thermography) [79]. Appropriate samples for the relevant diagnostic techniques include udder or teat skin swabs, teat duct material, milk, mammary tissue and blood samples [80].

Diagnosis of clinical mastitis is usually straight forward, based on findings of the clinical examination (swollen and painful udder, abnormal milk, high rectal temperature, lameness on the side of the affected gland) [81]. Further diagnostic tests (especially microbiological examinations) will support etiological diagnosis of mastitis, which is important for effective treatment [82]. In contrast, diagnosis of subclinical mastitis requires application of specific tests [83]. California Mastitis Test (CMT) and Somatic Cell Count (SCC) are regarded as the best indirect tests to diagnose intra-mammary infections (IMIs) in goats, when they are interpreted correctly [84]. Different threshold values for somatic cell counts have been proposed [85].

2.6. Treatment

Mastitis can be treated by the use of antibiotics through intramuscular as well as by intra mammary route followed by the identification of responsible pathogen as well as antibiotic sensitivity test to ensure proper treatment [86]. Microorganisms associated with mastitis in dairy goats are commonly controlled with antibiotics [87]. Dry off treatment has the advantage of antibiotics being used when the animal is not being milked, so that there is no milk loss and no antibiotic contamination of the bulk tank milk [88].

2.7. Control and Prevention

The fight against mastitis should not be limited to treating isolated clinical episodes, but also requires the surveillance and control of both, clinical and subclinical mastitis [89]. The knowledge of risk factors and etiological agents involved are also important in order to recommend specific and efficient control measures for both clinical and subclinical mastitis [45]. Farm management systems, milking management practices, breed considered or technical skills of the investigators are among the factors associated with the variability in the prevalence of goat mastitis between research reports [90]. The main control principles include: sound husbandry practices and sanitation, post milking teat dip, treatment of mastitis during non-lactating period, and culling of chronically infected animals [91].

Prevention of mastitis in small ruminants can be described upon programs that include vaccination, culling, application of good husbandry control and proper maintenance of milking machines, better milking routine without over milking and removal of clusters without impacts, and hygiene after milking [92]. Improved techniques depend on a better understanding of the nature of predisposing factors and breeding for resistance are the approach that is considered as a sustainable method for mastitis control [34].

2.8. Public Health Importance of Goat Mastitis Associated Bacterial Zoonoses

Contaminated milk can also serve as sources of a number of milk-borne infections to humans [93]. Milk produced by goats with mastitis presents a serious risk in terms of public health as it can be linked to milk-borne diseases for humans [16]. Some mastitic milk carries bacteria that can cause severe human illness. Pasteurization reduces the number of viable micro-organisms but often does not destroy toxins produced by bacterial pathogens, hence the concern when raw milk is consumed or when pasteurization is faulty [94,95]. The transfer of heat-stable toxins produced by mastitis-causing pathogens in milk is another serious potential concern [96]. The main pathogens causing infections and toxins related to the consumption of mastitic milk and its derivatives are Staphylococcus aureus, Salmonella spp., Escherichia coli, Mycobacterium bovis and Brucella melitensis [28].

Staphylococcus aureus are the most frequently diagnosed causal microorganisms of IMI in goats. Intramammary infections caused by these pathogens need to be treated with particular caution, because this bacterium is responsible for both acute clinical mastitis (gangrenous mastitis) and subclinical mastitis [13]. This pathogen can be found widely distributed in animals, and it is a contagious pathogen that can be transmitted from doe to doe during unhygienic milking procedures [97]. The possible contamination by Staphylococcus aureus in raw milk might occur from infected mammary glands [98]. The toxin, because it is thermostable, can remain in the food even after heat treatment, favoring the occurrence of intoxication, characterized clinically by nausea, emesis, malaise, general weakness, diarrhea, headache and abdominal pain [84].

Salmonellosis is an infectious disease of humans and animals which is caused by the bacteria of genus Salmonella and is clinically characterized by septicemia, acute enteritis or chronic enteritis [99]. Salmonella are Gram negative motile bacilli and amongst the leading causes of food borne illness in humans [100]. Salmonella spp. has a low prevalence in the case of mastitis in goats, however, salmonellosis is considered to be the disease most commonly associated with outbreaks of food poisoning [101]. Currently, more than 2.000 serotypes of Salmonella species are described, with Salmonella enterica serotype Typhimurium being the most prevalent in infections for human and domestic animals [102]. Salmonella spp. may be excreted directly in the milk by an infected animal [103].

E. coli is a normal inhabitant of the intestines of animals and humans but its recovery from food may be of public health concern due to the possible presence of enteropathogenic and/or toxigenic strains which lead to sever gastrointestinal disturbance [104]. While most strains of E. coli do not cause disease in humans, some are known to cause severe illness due to the production of toxins and/or other virulence factors [105]. In recent years, new pathogenic bacteria have emerged throughout the food chain [106]. It has been reported, for instance, that new milk-borne bacterial pathogens with extremely severe health effects, such as E. coli 0157:H7, have emerged [107]. E. coli O157 is the most common type of E. coli infection that cause intestinal infections, urinary infections, septicemia, meningitis, and other infections [108]. Contamination of milk with pathogenic E. coli occurs through faecal material present on teats and udder, or from the environment [25]. Faecal contamination of udders is one of the risk factors triggering pathogens to enter the raw milk [109].

Tuberculosis in small ruminants is characterized by progressive cachexia, dry, short and repetitive cough, mastitis and infertility, and localized or generalized lymphadenomegaly may occur. It is mainly caused by Mycobacterium bovis, although M. avium and M. tuberculosis have been isolated occasionally [110]. Tuberculosis (TB) is also a leading zoonotic infectious cause of human death worldwide, which is transmitted to humans through consumption of raw, unpasteurized or contaminated milk, dairy products and other animal products from infected animals (e.g. cattle, goat, deer, buffalo, sheep and camel) [111]. Humans infected with open tuberculosis due to M. bovis can transmit the bacteria to animals via the aerogenous route by spitting or coughing [112]. The symptoms in humans are a cough, fever, sputum that in the advanced stage of the disease can present blood, difficulty breathing and progressive weight loss [113].

Brucellosis is one classical example of milk-borne infection, Brucella spp being transmitted from goats to humans either through direct contact or through the milk of the infected animal, particularly since the appearance and taste of the milk are rarely affected by the presence of the bacteria [106]. Approximately two thirds of acute natural B. melitensis infections of goats during pregnancy lead to infection of the udder and excretion of the bacteria in milk during the subsequent lactation [114]. Progressively, intermittent shedding of the agent in milk occurs in animals with persistent infection of the udder [115]. Brucella melitensis may cause inflammation of the mammary tissue, which is the most probable cause of reduced milk production in infected animals [116]. Once transmitted to humans, Brucella is responsible for a type of granulomatous hepatitis or an acute febrile illness which can, at times, persist and progress to a chronically incapacitating disease with serious complications [117].

3. Conclusion and Recommendations

Mastitis is a significant disease of dairy farms throughout the world. The diagnosis of mastitis in goats is similar to that for cows and other animals. Subclinical mastitis is detectable by the monitoring of somatic cell counts but it needs careful interpretation due to the higher rate of epithelial cell sloughing and the presence of cytoplasmic masses in goat milk. Careful diagnosis and treatment of mastitis in goats affords the best opportunity for a successful outcome when therapy is required. The prevention of mastitis through the establishment of good husbandry practices, sanitation, sound milking procedures including post-milking-teat-dipping and treatment during the non-lactating period, and culling of chronically infected can alleviate the loss due to caprine mastitis. The major obstacle in treating mastitis is antibiotic resistance; therefore, susceptibility test should be taken before treatment. Zoonotic diseases pose a serious threat to human health in developing countries.

Based on the above conclusive remarks, the following points are forwarded as recommendation.

- The periodic assessment of preventive measures for mastitis should be practiced.
- Maintaining clean and hygienic environment around animals.
- Vaccines protecting against major pathogens like Staphyloccus Aureus should be developed.
- Further studies on the status, distribution and the risks of milk-borne infections should be properly assessed and their control and prevention methods should be followed.

Declarations

Author's Contributions

Mohammed Bedruddin: Read and approved the final version of the manuscript.

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Ethical Approval and Consent to Participate

The protocol of my current review whose approved by college of veterinary medicine veterinary public health department of Haramaya University, Ethiopia and the ethical clearance who waived due to no major involvement of humans and animal subject welfare of ethical issues.

Competing Interests

The author declare that they have no competing interests.

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