

## Review Article

# Bibliographic Synthesis on the Influence of Cow Mastitis on Fresh Milk Quality

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### Abstract:

Mastitis in lactating cows lead to a decrease in the overall cow production; make milk unfit for human and calf consumption; deteriorate milk quality. However, data are not updated on the influence of mastitis on the physicochemical and microbiological quality of milk. Therefore, the present review was made to highlight the current state of knowledge on prior research on the impact of mastitis on milk quality, and to identify the shortcomings of these studies. Two themes were addressed to achieve this. We started by reviewing the prevalence, aetiology and factors associated with the occurrence of mastitis in the African continent. Then, we compared the variation of chemical components of mastitis milk in several studies. Our analysis shows that subclinical mastitis is predominant in Africa, with most prevalence higher than 50%. The majority of authors (83.33%) claimed that *Staphylococci* are the main cause of mastitis. The breed (83.33%) and lactation stage (66.66%) were the two most cited factors contributing to the occurrence of mastitis. Data collected on the chemical components of mastitis milk came mostly from studies prior to the year 2000. Several contrary opinions (increase/decrease/no variation) were stated by authors on the variation of chemical components of mastitic milk, specifically on fat, lactose and crude protein contents. Overall, it is challenging, if not impossible, to draw a definitive conclusion about the influence of mastitis on the chemical composition of milk for most chemical parameters, because the data examined in relation to the chemical components of milk with mastitis seem rather inconsistent.

**Keywords: Bovine mastitis, prevalence, aetiology, associated factors, cow milk quality.**

## I. Introduction

Bovine mastitis is most often due to an udder infection, characterized by a decrease in milk yield and quality, as well as a possible deterioration of the animal's general health (Benhamed, Moulay, Aggad, Henni, & Kihal, 2011). Two types of mastitis are frequently encountered in dairy production, including subclinical and clinical mastitis (Wallace, 2007). According to Rakotozandrindrainy and Foucras (2007), *Staphylococcus aureus*, *Escherichia coli*, *Streptococcus agalactiae*, and *Klebsiella* are the primary microorganisms that cause mastitis in dairy farms. Indeed, negative effects of mastitis in cows are numerous, including a decrease in the overall production level of the animals; makes the milk unfit for human consumption and that of the calf; deteriorates the quality of milk both nutritionally, microbiologically and physicochemically (Millogo, Sissao, & Ouédraogo, 2018); constitute a gateway for other opportunistic bacteria that could be harmful to the health of livestock (Traore et al., 2004).

Numerous studies on the prevalence and identification of

mastitis causative agent, as well as on the qualitative analysis of fresh milk, have been carried out globally and across Africa (Ngungwa et al., 2018; Millogo Sissao, & Ouédraogo, 2018; Benhamed et al., 2011; Rakotozandrindrainy & Foucras, 2007). However, there haven't been many recent investigations on how these mastitis directly affect the chemical changes and microbial components of raw milk. Our investigation indicates that the most recent studies on the nutritional value of mastitis milk were conducted before the year 2010. (Wolanciuk, & Brodziak, 2009; Andreatta et al., 2007; Ogola, Shitandi, & Nanua, 2007; Bansal, Hamann, Grabowskit, & Singh, 2005; Hagiwara, Kawai, Anri, & Nagahata, 2003). In addition, none of the above mentioned studies was conducted in Cameroon. Hence the interest of this review which aims to bring out the state of the art of previous studies on the influence of mastitis on the quality of raw milk. Specifically, the review will focus on the prevalence and factors associated with mastitis in Africa; the main aetiological agents involved in mastitis; variation in the chemical components of mastitis milk.

## II. Methodology

### II.1. The Research Strategy

In this analysis, various study types (including longitudinal studies and cross-sectional surveys) were taken into consideration. Results were gotten from investigations carried on mastitis screening and on the analysis of the microbiological and physicochemical quality of milk from local and improved breeds of well-defined milking cows' populations. Articles included in this review were searched using PubMed and Google Scholar databases published up to June 2021. The search was conducted using the following search terms: "Bovine mastitis, prevalence, aetiology, associated factors, cow milk quality".

### II.2. Selection criterion

The following papers were included in this review:

- Studies with a clear description of the various mastitis screening methods used;
- Articles with a clear description of the laboratory procedures used for microbiological and chemical sample analysis;

- Articles published in either English or French;
- Research conducted across Africa in general and in Cameroon in particular.

### II.3. Data extraction

To find potential studies based on titles and abstracts, data extraction was done using the inclusion criteria. A standardised Excel spreadsheet was created by extracting pertinent data from the chosen publications. Data were extracted using a predefined form, which included the following information: Publication data (journal, authors, study period, year of publication); country of investigation in Africa; Mastitis type and its prevalence; Major aetiological agents; associated factors, Mastitis' impact on the chemical components of milk; references.

### II.4. Critical Assessment

The critical appraisal was based on a weighted tool developed by Folegatti *et al.* 2017; tool based on the modified checklists proposed by Downs and Black and the NOS (**Table 1**). Articles were evaluated against a score-based system that combined elements of both scales, Articles with a score > 60% were included in this review.

**Table 1 : Critical appraisal tool used in this review**

Critical Appraisal Tool	Score
1. Was the research question or objective in this paper clearly stated?	1 point
2. The study clearly describes the exposures and outcomes	1 point
3. The study clearly describes the basic characteristics of the participants	1 point
4. Results were adjusted for potential confounding variables by stratification or multivariate analysis	1 point
5. The statistical test used to analyze the data is clearly described and appropriate, and the measure of association is presented	1 point
6. The study provides information on the characteristics of sight loss: numbers and reasons	1 point
7. Participants were followed for the same time period or the study was adjusted for different follow-up times	1 point
8. The measures used for the main results were accurate: description of the diagnostic technique for Brucellosis	1 point
9. The demographic characteristics were comparable or adjusted: geographical area of breeding, speculation...	1 point
10. Participants from different groups were recruited during the same period	1 point
11. Representativeness of the sample i. Representative of the average of the target population: all subjects or random sampling ii. Somewhat representative of the average target population: non-random sampling	1 point 1 point
12. Sample size Justified and adequate	1 point
13. Verification of exposure (risk factor) i. Validated measurement tool or non-validated measurement tool, but the tool is available or described ii. No description of the measurement tool	1 point

## III. Results & Discussion

### III.1. Prevalence, causal agents, and contributing factors of cow mastitis in Africa and Cameroon

#### III.1.1. Mastitis Prevalence

Mastitis is still a hot problem and a topical issue in most African nations, including Cameroon, due to the disease's economic impact and the variety of aetiological agents in dairy farms. The variation in prevalence between countries (**Table 2**) could be explained by the variability of breeds screened for mastitis. Indeed, screening was mostly done on improved cows breed in some

countries, such as Cameroon, Kenya, and Tunisia, where the prevalence was high, at 68.3%, 64%, and 52%, respectively (Mureithi & Njuguna, 2016; Ngungwa et al., 2018a; Sadak, Mighri, & Kraiem, 2013). This could be justified by the fact that improved breeds with high dairy performance, such as Holsteins, are very often more susceptible to subclinical mastitis than local breeds (Hamlaoui, 2017). Furthermore, the predominance of subclinical mastitis (up to 60%) in countries, such as Cameroon (Iraguha et al., 2015; Ngungwa et al., 2018), could be explained by the fact that this type of mastitis is silent and very often detected late, unlike clinical mastitis, which is visible and therefore very detectable, allowing early management. The rises in mastitis prevalence (clinical and subclinical) that different writers have noted in various nations, are alarming evidence and warning signs of the extent to which the efforts made to date in fighting against mastitis remain inadequate throughout the African continent.

**Table 2 : Cow mastitis in Africa and Cameroon: Prevalence, aetiological agents, and contributing factors**

Country	Year	Prevalence	Major aetiological agents responsible of bovine mastitis	Associated factors (p < 0.05)	Reference
Ethiopia	2021	Subclinical Mastitis (34.9%); Clinical Mastitis (3.4%)	<i>Staphylococcus aureus</i> (40,3%), <i>Streptococcus</i> species (24,3%), <i>Coagulase negative Staphylococcus</i> (12,5%), <i>E. coli</i> (8,3%), <i>Staphylococcus hyicus</i> (3,5%), and <i>Staphylococcus intermedius</i> (1,4%).	Breed, age, weight, herd size	Fesseha, Mathewos, Saliman, & Amanuel, 2021
Senegal	2017	CMT (11.9%) CCS (10.9%)	-	Breed, lactation stage, number of births	Kalandi et al., 2017
Kenya	2016	Subclinical Mastitis (64 %)	-	Breed, hygiene of the udder, lactation stage and soil type	Mureithi & Njuguna, 2016
Rwanda	2015	Subclinical Mastitis (52 %)	Total Coliforms (87.5%), Environmental Staphylococci (6,25%), <i>Staphylococcus aureus</i> (6,25%)	Hygiene of the udder, state of cleanliness in cows, breed, age & lactation stage	Iraguha, Hamudikuwanda, & Mushonga, 2015
Algeria	2011	Mastitis CMT (55.16%)	<i>Staphylococcus aureus</i> (30,76%), <i>Streptococcus</i> sp (30,76%), <i>E. coli</i> (23,07%),		Benhamed, Moulay, Aggad, Henni, & Kihal, 2011
Tunisia	2016	Subclinical Mastitis (52%)	-	Milking conditions, state of cleanliness in cows,	Sadak, Mighri, & Kraiem, 2013
Nigeria	2011	Mastitis CCS (52%)	<i>Staphylococcus aureus</i> (22,8%), <i>Staphylococcus epidermidis</i> (10,9%), <i>Streptococcus</i> spp. (14,1%), <i>Corynebacterium</i> spp (15,2%), <i>Bacillus</i> spp (7,6%), <i>E coli</i> (9,78%), <i>klebsiella</i> spp. (4,35%), <i>Proteus</i> spp. (8,69%), <i>Enterobacter</i> spp. (1,09%), <i>Salmonella</i> (2,17%) and <i>Providentia</i> spp (3,26%)	-	Junaidu, Salihu, Tambuwal, Magaji, & Jaafaru, 2011
Madagascar	2007	Mastitis CMT (46.64%)	<i>Staphylococcus aureus</i> (29,5 %), <i>Coagulase negative Staphylococcus</i> 33,7%), <i>E.coli</i> (19,3 %), Total Coliforms (87.5%), Environmental Staphylococci, <i>Haemolytic Streptococci</i> (9,8 %), <i>Klebsiella</i> sp (4,9 %) et <i>Streptococcus agalactiae</i> (2,6 %)	-	Rakotozandrindrainy & Foucras, 2007
Cameroon	2018	Subclinical Mastitis (60 %); Clinical Mastitis (8.3 %)	<i>Staphylococcus</i> spp. (33,8%), <i>Streptococcus</i> spp. (26,4%) and <i>Escherichia coli</i> (22,0%)	Herd size, breed, age, parity, lactation stage, daily milk milking	Ngungwa et al., 2018

### III.1.2. Major aetiological agents responsible of bovine mastitis

Concerning the major aetiological agents responsible of mastitis (Table 2), *Staphylococcus aureus* ranks first. Indeed, 05 out of 06 authors (83.33%), cited it as the dominant aetiological agent of mastitis in cattle farming (Benhamed et al., 2011; Fesseha, Mathewos, Saliman, & Amanuel, 2021; Junaidu, Salihu, Tambuwal, Magaji, & Jaafaru, 2011; Ngungwa et al., 2018; Rakotozandrindrainy & Foucras, 2007). In addition, this contagious pathogen is capable of surviving and proliferating on the skin, teats and udders. Staphylococci can also be transmitted to other quarters and animals (Bradley, 2002; Oviedo et al., 2007). The second most cited agent by the authors (66.67%) was *Streptococcus* spp (Benhamed et al., 2011; Fesseha, Mathewos, Saliman, & Amanuel, 2021; Junaidu, Salihu, Tambuwal, Magaji, & Jaafaru, 2011;

Ngungwa et al., 2018). In fact, this pathogen could either be transmitted to other quarters and other animals or behave as an opportunistic environmental pathogen, which could penetrate the mammary gland via the teat canal and induce inflammation (Bradley, 2002). However, they are often quickly eliminated from the udder after repeated milking. This is the case for *Streptococcus agalactiae* and *Streptococcus uberis* (both pathogens with an environmental and mammary reservoir) (Oviedo et al., 2007). It is therefore necessary firstly to emphasise various hygiene measures in the farm and secondly to insist on udder hygiene before, during and after milking.

### III.1.3. Factors associated with mastitis in dairy farms

The authors most commonly listed breed, lactation stage and age of animals as the main factors related with the

development of mastitis in livestock, accounting for 83.33%, 66.67%, and 50% of cases, respectively (**Table 2**). Improved breeds with high dairy performance are more prone to mastitis than local cows (Shyaka, Kadja, Kane, Kaboret, & Bada Alamedji, 2010). As for age and lactation stage, according to a study by Poutrel, the frequency of udder infections and clinical mastitis increases with age and, more specifically, with the number of lactations (Poutrel, 1983).

### III.2. Impact of mastitis on the chemical quality of raw cow's milk

According to several authors, a decrease in milk fat concentration during mastitis is unavoidable (**Table 3**), due to a reduction in the synthesis and secretion capacity of the mammary gland (Rowland *et al.*, 1959; Seelemann, 1963). However, results from other authors are contradictory, since some authors found an increase in fat concentration in clinical mastitis, explained by the presence of fat in the milk, resulting from lysis of the lipoprotein membranes of bacterial cells (Andreatta *et al.*, 2007; Bansal *et al.*, 2005). In addition, an increase in volatile fatty acids (Auldism *et al.*, 1996; Lee, Yu, Back, & Yoon, 1991) and certain proteins (albumin, immunoglobulin G and lactoferrin) was reported in the milk of mastitis cows (Anderson & Andrews, 1977; Baranova & Belov, 1993; Hagiwara *et al.*, 2003). This could be explained by alteration of the milk fat globule membrane by leukocyte

lipases or by hydrolysis of lipoprotein membranes, two phenomena that can promote lipolysis. As for the influence of mastitis on lactose concentration, some authors found that lactose levels in milk tend to decrease during mastitis (Auldism *et al.*, 1996; Klei *et al.*, 1998), while other authors found no significant variation (Teute, 1961). Overall, the results discussed seem somewhat contradictory and it is difficult, if not impossible, to draw a clear conclusion on the impact of mastitis on the chemical composition of milk for most parameters. This could be partly explained by the sampling methods used to take different milk samples. In fact, some studies are carried out on mixed milk, while others are carried out on milk taken from one or more udder quarters. As a result, the analyses carried out on these different milk samples could lead to variable results. What's more, these divergent results can also be explained by the different pathogens responsible for mastitis. The symptoms of mastitis and their impact on milk yield and composition can differ considerably depending on the bacterial species involved in the mastitis outbreak (Marechal *et al.*, 2011). Among the pathogenic bacteria involved in mastitis, some cause changes in milk composition, while others have little or no effect on milk composition. For example, *C. bovis* does not alter the composition of milk, whereas the changes in milk are more marked in the case of *E. coli* mastitis (Coulon *et al.*, 2002).

**Table 3 : Effect of mastitis on the chemical components of milk**

Chemical Components	Impact on Milk	Reference
	?	Andreatta <i>et al.</i> , 2007; Bansal, Hamann, Grabowskit, & Singh, 2005
Total fat content	?	Rowland, Neave, & Olivier, 1959; Seelemann, 1963
	-	Waite & Blackburn, 1957
Volatile fatty acid	?	Auldism <i>et al.</i> , 1996; Lee, Yu, Back, & Yoon, 1991
Lactose	?	Auldism <i>et al.</i> , 1996; Klei <i>et al.</i> , 1998
	-	Teute, 1961
Crude protein	?	Andreatta <i>et al.</i> , 2007; Barlowska, Litwinczuk, Wolanciuk, & Brodziak, 2009
	-	Waite & Blackburn, 1963
Total casein	?	Coulon <i>et al.</i> , 2002; Klei <i>et al.</i> , 1998
Albumin	?	Kitchen, Middleton, Durward, Andrews, & Salmon, 1980
Immunoglobulin G	?	Anderson & Andrews, 1977; Baranova & Belov, 1993
Lactoferrin	?	Hagiwara, Kawai, Anri, & Nagahata, 2003
<b>Salt</b>		
Na	?	Auldism, Coats, Rogers, & McDowell, 1995; Kitchen <i>et al.</i> , 1980
K	?	Auldism, Coats, Rogers, & McDowell, 1995; Ogola, Shitandi, & Nanua, 2007
Cl	?	Muir, 1996; Ogola, Shitandi, & Nanua, 2007
Total Ca	?	Auldism, Coats, Rogers, & McDowell, 1995; Coulon <i>et al.</i> , 2002
Total Mg	?	Singh, L.N Ganguli, 1975
P	?	Obersler, Aguggini, Bergamaschi, Chiesa, & Perini, 1961
	?	Ali, Andrews, & Cheeseman, 1980; Coulon <i>et al.</i> , 2002

Arrows indicate an increase (↑) or decrease (↓); a question mark (?) indicates that the relationship is suspected but not clearly demonstrated; a dash (-) indicates that no variation was observed.

### IV. Conclusion

The aim of this review was to bring out the state of the art of previous studies on the influence of mastitis on the quality of raw milk in several African countries. The prevalence rate noted by several authors is a warning sign indicating how insufficient the current anti-mastitis initiatives are across the

African continent. In addition, given the primary aetiological agents responsible for mastitis, it is essential to underline various farm-wide cleanliness practises and to insist on udder hygiene before, during, and after milking. Indeed, this disease is the greatest world health and economic concern in dairy farms. Therefore, an accurate knowledge of the

epidemiological data on cattle mastitis and its effect on milk quality would help to create a better mastitis control program, hence increasing milk quality and quantity throughout the African continent in general and throughout Cameroon in particular.

In perspective to this review, the lack of contemporary information on the effects of mastitis on the nutritional content of raw milk justifies the importance of further in-depth investigation on the chemical characteristics of raw cow's mastitis milk.

## V. Conflicts of Interest


The study was conducted without any conflict of interest.

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