

Relationship between Somatic Cell Counts, Mastitis and Milk Quality in Ettawah Grade and PESA Goats

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Abstract

Mastitis is a bacterial disease that leads to increased somatic cell counts and reduced milk quality in dairy goats. Reduction in quality is manifested through a reduction in fat, protein, lactose content and an increase in milk somatic cell counts and salts content. Thus mastitis affects productivity of animals and hence their economic value. The aim of this study was to analyze the effects of somatic cell counts (SCC) and mastitis on milk quality in PE and PESA. On-Farm mastitis tests were performed on 38 lactating dairy goats and milk samples were collected from both mastitis positive and healthy animals from which quality parameters were measured using a milko tester while bacterial isolation and enumeration were done following standard protocols. Data was analyzed descriptively and the results showed that somatic cell counts and somatic cell score correlate positively with mastitis ($P < 0.05$). Lactose and fat content decreased with severity of mastitis in both breeds whereas in PESA protein content increased with mastitis. Salt content increases with mastitis in both breeds. *S. aureus* was the most isolated bacteria and associated with high SCC whereas *E. coli* was poorly isolated. The study concludes that mastitis leads to increased SCC and reduced milk quality in dairy goats.

Keywords: Somatic cell counts, mastitis, milk quality, PE, PESA

Introduction

Dairy goats are distributed all over Indonesia with large numbers found in Java Island. Kacang goat and Ettawah grade goat are the oldest and most abundant breeds [1,2]. Other breeds include Saanen, PESA, Boer goat, Angora and Gembrong goat. The latter is localized in Bali while Saanen was imported from Australia [3]. Dairy goats play a very crucial role in livelihoods of small holder farmers and the economy of the country. They provide milk and meat for human nutrition and manure that is used for fertilizing the soil for crop production. Goat milk is recommended for people who are allergic to cow milk as goat does not cause allergic reactions. It is also alleged to have medicinal properties.

Milk quality is a very important parameter that determines milk's end use, fitness for human consumption and its shelf life. Besides milk adulteration and somatic cell counts (SCC), milk bacteriological count is an important index of milk quality and it is used by dairy industries and dairymen as a means to gauge milk quality. Milk may be contaminated with bacteria during milking and or during handling and storage. Bacteria may also come from the livestock attendant, from the environment, other infected animals. To infect animals, bacteria enters the mammary glands through teats canal, causes irritation and swelling in the udder which finally leads to increased SCC. The bacterial population and

type of bacteria involved in udder inflammation are important determinants of somatic cell counts and the severity of mastitis [4]. Literature shows that there is a positive correlation between SCC and mastitis whilst quality parameters correlate negatively with both SCC and mastitis in cows [5]. However, in dairy goats increased SCC does not necessarily translate into mastitis as it has been observed that SCC increase during lactation regardless of mastitis status [6]. Bacteria that comes the environment where animals live causes environmental mastitis while bacteria that are transmitted from other animals causes infectious mastitis. Both environmental and infectious mastitis can be controlled and kept minimal by keeping the environment dry and clean and by separating sick animals from healthy ones.

Several studies report a reduction in dairy products yield as SCC and total bacterial counts increase [7,8]. Cheese yield and quality and milk shelf life show most negative responses [9,10]. These changes are caused by proteolysis and lipolysis that are further accelerated by high storage temperatures [11,8].

In Indonesia, small scale dairy farmers are characterized by manual operational procedures, low quality storage and cooling facilities which makes milk more susceptible to bacterial contamination. Mastitis is estimated to occur at a rate of 75 - 83 % accompanied by 45 % reduction in milk quantity and 40 % reduction in quality [12,13] and the costs associated to mastitis are estimated to be around Rp 3,000,000 per animal per annum [14]. The level of bacterial contamination may differ between farms and regions. In an attempt to monitor goat milk quality in Bogor, this research was conducted with the aim to investigate the relationship between SCC mastitis and milk quality. Ettawah Grade goat and PESA were used because they are the most common breeds within the vicinity of Bogor regency.

Materials and methods

The research was conducted from January to May 2012. It was conducted using a total sample of 38 dairy goats from the institutes [Cordero dairy farm (13 PE goats), Caprito dairy farm (16 PESA goats) and the Livestock Research Centre in Bogor (9 PESA goats)] that gave authority for their farms to be used in this study. The sample population was composed of both mastitis positive (71 %) and healthy goats (29 %). The sample population was free from physical injuries on the udder which could predispose them to mastitis. Detailed production records could not be secured hence production parameters were not included in analysis.

The lactating flock from each farm was tested for mastitis using IPB1 reagent following standard California mastitis protocols. Scores were assigned to mastitis test results on the basis of degree of gelling where "0" signified absence of mastitis and there was no gel formed, mastitis 1- weak gel was formed which disappeared with continued swirling, mastitis 2- a thicker gel that collects in the center was formed. It poured out leaving some little milk behind while mastitis 3 formed a very thick gel that collected at centre of the cup and poured out without leaving any milk in the cup. Milk samples were collected from all mastitis positive animals while mastitis negative animals were sampled at random for comparison. The samples (100 ml) were aseptically collected by milking directly into sterile plastic bags after discarding the forestrip milk. The samples were kept in a cooler box with ice and then transported to the laboratory where they were tested within 6 h of collection. Samples were collected from each farm on weekly basis for a period of a month.

Milk quality tests were performed at Bogor Agricultural University, in the milk technology laboratory. Fat content, solid non-fat (SNF), specific density, protein, freezing temperature, salts and lactose were measured using milko tester (Master Pro). Total solids (TS) in the milk were calculated from fat % and milk density using Richmond's formula [15] shown below.

$$TS = \frac{LR}{4} + (1.22 * \text{fat } \%) + 0.72 \quad (1)$$

where

TS = Total solids,

LR = Lactometer reading (Milk density).

Milk SCC were determined following the direct microscopic somatic cell counts (DMSCC) technique [16]. A milk sample (0.01 ml) was put on a glass slide then spread evenly within the area of 1 cm² and air dried. The sample was fixed on the slide by heating over the Bunsen burner. The slides were then put in ether alcohol for approximately 1 - 2 min to remove fat and then stained with methylene blue loeffler. Excess dye was removed by washing the slides with water. The slides were then dipped in alcohol (96 %) for 5 min to remove excess dye then followed by drying and counting total SCC. The slides were viewed under the microscope for counting where counts were made on 30 spots along the line to avoid double counting and the average SCC were determined and converted to total SCC/ml of milk following [16].

$$\Sigma SCC = \frac{10\,000}{\pi r^2} * \frac{SCC}{spot} \quad (2)$$

where

r (0.08) is the radius of the microscope lens.

SCC were then standardized to linear scores following [17].

$$scs = \left(\frac{\ln\left(\frac{SCC}{100}\right)}{0.69317} \right) + 3 \quad (3)$$

where

SCS are the Somatic cell Scores.

Bacterial isolation and enumeration were done to confirm mastitis etiology. Bacterial isolation was done following standard protocols as per oxoid manual using Eosin Methylene Blue Agar and Baird-Parker agar while total plate count (cfu/ml) was computed following Bacteriological Analytical Manual (BAM) using the formula below [18].

$$\frac{cfu}{ml} = \frac{\Sigma c}{[(1*n_1)+(0.1*n_2)]*(d)} \quad (4)$$

where

ΣC is the sum of colonies on the plates counted.

n_1 is the number of plates in the first dilution counted

n_2 is the number of plates in the second dilution counted

d is the dilution from which the first counts were obtained

CFU/ml = colony forming units per ml of milk sample.

Data was analyzed descriptively and Pearson correlations coefficients between milk quality parameters were performed [19]. A T-test was also performed on milk quality parameters between mastitis positive and mastitis negative milk.

Results and discussion

Differences on milk quality between mastitis positive and mastitis negative animals

This study found that 71 % of the sample population was mastitis positive while 29 % was mastitis negative. 11 % of the mastitis positive animals had SCC below one million cells/ml of milk while 45 % of the mastitis negative animals had their SCC above 1,000,000.

Table 1 compares the means for quality parameters between mastitis positive and mastitis negative milk. The results showed that only SCC and SCS were significantly different ($P < 0.05$) between 2 groups while the other parameters were not statistically different ($P > 0.05$).

Table 1 T-test and P-value for milk quality factors of mastitis positive and mastitis negative animals (mean \pm SD).

Parameter	Mastitis negative animals (n = 11)	Mastitis animals (n = 27)	p-value
SCC	1,170,000 ^b \pm 700,000	1,900,000 ^a \pm 200,000	0.004
SCS	16.26 ^b \pm 0.881	16.93 ^a \pm 0.886	0.005
Fat	6.84 \pm 1.86	6.20 \pm 0.10	0.180
SNF	9.434 \pm 0.514	9.392 \pm 0.89	0.788
Freezing point	-0.4821 \pm 0.08621	-0.392 \pm 0.368	0.067
Milk density	1.03029 \pm 1.98*10 ⁻⁴	1.03053 \pm 4.3*10 ⁻⁴	0.719
Protein	5.16 \pm 0.36	5.095 \pm 0.53	0.428
Total solids	9.32 \pm 2.27	8.54 \pm 2.56	0.180
Lactose	3.68 \pm 1.3	3.44 \pm 0.488	0.400
Salts	0.8509 \pm 0.061	0.8509 \pm 0.85	0.347

Means with the same superscripts indicate no statistical difference

Table 2 Mean quality scores (\pm SD) for each mastitis test score in PE and PESA milk.

Parameter	Breed	Mastitis test score \pm SD			
		Mastitis negative (0)	Mastitis (1)	Mastitis (2)	Mastitis (3)
SCC (log ₁₀)	PE	6.1 \pm 808212	6.181 \pm 711592	6.186 \pm 544062	
	PESA	5.954 ^b \pm 379144	6.188 ^b \pm 834788	6.349 ^{ab} \pm 1165644	6.857 ^a \pm 3521994
SCS	PE	16.338 \pm 0.950	16.711 \pm 0.792	16.811 \pm 0.578	
	PESA	16.021 ^b \pm 0.660	16.811 ^b \pm 0.801	17.275 ^{ab} \pm 0.732	18.974 ^a \pm 0.900
Fat%	PE	7.581 \pm 1.270	7.547 \pm 2.434	7.223 \pm 1.128	
	PESA	4.319 ^b \pm 1.171	6.031 ^a \pm 2.003	5.865 ^{ab} \pm 2.038	5.81 ^{ab} \pm 2.44
SNF%	PE	9.415 \pm 0.557	9.707 \pm 1.688	9.347 \pm 0.489	
	PESA	9.498 \pm 0.374	9.170 \pm 0.504	9.301 \pm 0.456	9.440 \pm 1.170
Density	PE	1.0298 \pm 1.91*10 ⁻⁴	1.0307 \pm 4.93 *10 ⁻⁴	1.0296 \pm 1.90*10 ⁻⁴	
	PESA	1.0319 \pm 1.37*10 ⁻⁴	1.0295 \pm 2.47 *10 ⁻⁴	1.0300 \pm 2.42 *10 ⁻⁴	1.0307 \pm 3.90 *10 ⁻⁴
Fp (°C)	PE	-0.4872 \pm 0.0944	-0.4562 \pm 0.1672	-0.4678 \pm 0.0324	
	PESA	-0.4647 \pm 0.0529	-0.45989 \pm 0.03604	-0.258 \pm 0.651	-0.190 \pm 0.535
Protein%	PE	5.2435 \pm 0.3362	5.385 \pm 5.385	5.1900 \pm 0.2318	
	PESA	4.942 \pm 0.362	4.9558 \pm 0.3255	4.9854 \pm 0.3007	5.137 \pm 0.677
Total solids (TS)	PE	10.227 \pm 1.549	10.185 \pm 2.971	9.790 \pm 1.376	
	PESA	6.247 \pm 1.429 ^b	8.335 \pm 2.443 ^a	8.133 \pm 2.486 ^{ab}	8.07 \pm 2.98 ^{ab}
Lactose%	PE	3.676 \pm 1.458	3.593 \pm 0.883	3.3022 \pm 0.2327	
	PESA	3.6850 ^a \pm 0.0913	3.3910 ^b \pm 0.3865	3.4378 ^b \pm 0.3833	3.1933 ^c \pm 0.0603
Salts%	PE	0.8724 \pm 0.0655	0.8858 \pm 0.1556	0.8522 \pm 0.0452	
	PESA	0.8480 \pm 0.0466	0.8261 \pm 0.0548	0.8356 \pm 0.0528	0.8567 \pm 0.1097

Notes: PE: Healthy, n = 6; Mastitis 1, n = 4; Mastitis 2, n = 3; Mastitis 3, n = 0
 PESA=Healthy, n = 5; Mastitis1, n = 9; Mastitis 2, n = 10; Mastitis 3, n = 1
 Means in the same row with different superscripts are significantly different

Table 2 shows that in PE, SCC and SCS did not differ significantly between healthy goats and different levels of mastitis status whereas PESA displayed significantly elevated SCC and SCS in mastitis 2 and 3. PESA showed lower SCC against PE in healthy animals whereas in mastitis 1 and 2 PESA was higher although the differences were not statistically significant in all cases. Mean fat content showed a decreasing pattern with an increase in mastitis status in PE even though the differences were not significant ($P > 0.05$) whereas in PESA, fat content was significantly lower in healthy goats, highest in mastitis 1 animals and decreased with mastitis status thereafter. Milk specific gravity (density) and freezing temperature (Fp) did not show significant differences between breed and mastitis status for both PE and PESA. Total solids in milk were significantly lower in healthy PESA than in healthy PE ($P = 0.001$). PESA with mastitis 1 showed significantly higher total solids as compared with healthy ones whereas PESA with mastitis 2 and 3 showed statistically different total solids content. Lactose content also showed statistically insignificant decreasing pattern in PE with an advance in mastitis status whereas PESA showed a significant decrease in average protein content as mastitis increase. Mean salts content showed an increasing pattern from healthy animals to mastitis 1 and subsequently dropped in mastitis 3 whereas PESA displayed an increasing pattern although the differences were not significant.

Correlations between milk quality parameters

Table 3 shows that SCC and milk quality parameters are not correlated ($P > 0.05$) except for SCC and SCS ($P < 0.05$). A significant negative correlation was observed between SCS and SNF ($P = 0.019$) and SCS and milk density ($P = 0.016$). Positive correlation also exists between fat and SNF and between SNF and milk density where SNF and milk density correlate negatively with SCC. This gives an impression that as milk somatic scores increases, milk density and SNF will show a significant decrease and fat will be expected to tag along with the latter. A significant positive correlation was also observed between total solids with fat, SNF and proteins. The results also indicated that elevated SCC does not necessarily always translate into mastitis and successful isolation of the bacteria (results not shown) as some animals showed very elevated SCC yet bacteria could not be isolated. Bacteriological tests showed that *S. aureus* was the most commonly isolated bacteria and associated with high SCC in animals with mastitis while *E. coli* was poorly isolated and the average total plate count was $2.8 \times 10^8 \pm 1.4 \times 10^6$ (cfu/ml).

Table 3 Pearson correlation values and P values for milk quality factors.

	SCC	SCS	Fat	SNF	Milk density	Freezing point	Protein	Lactose
SCS	0.871 0.000							
Fat	0.091	0.093						
	0.396	0.384						
SNF	-0.096	-0.246	0.211					
	0.368	0.019	0.043					
Milk Density	-0.135	-0.254	-0.182	0.750				
	0.203	0.016	0.083	0.000				
Freezing point	0.012	0.069	-0.193	-0.269	-0.166			
	0.912	0.517	0.065	0.009	0.113			
Protein	-0.046	0.188	0.472	0.896	0.559	-0.255		
	0.668	0.076	0.000	0.000	0.000	0.014		
Total solids	0.103	0.107	1.00	0.214	-0.181	-0.194	0.474	-0.075
	0.348	0.327	0.000	0.044	0.090	0.069	0.000	0.485
Lactose	-0.147	-0.152	-0.076	0.283	0.239	-0.096	0.140	
	0.166	0.151	0.473	0.006	0.022	0.360	0.184	
Salts	-0.110	-0.281	0.234	0.909	0.700	-0.219	0.931	0.162
	0.302	0.007	0.025	0.000	0.000	0.036	0.000	0.123

The boldfaced values are significant ($P < 0.05$)

Discussion

Agricultural extension programs that focus on mastitis control emphasize implementation of selection for lower SCC and management practices that minimize the risks of infection [20] and such programs have a potential to reduce mastitis [21]. Proper milking procedures and hygienic milk handling are an integral part of such programs and they are effective in maintaining lower bulk milk SCC while sustaining hygiene. Nevertheless, mastitis is still a problem in the dairy industry. Literature indicates that mastitis causes alteration in functional characteristics of milk and protein quality; longevity and reproductive performance of animals are also affected [22,10]. The results for SCC and SCS showed an increasing behavior with intensity in mastitis where PESA displayed higher SCC and SCS than PE. The results for lactose and fat concur with [23] in that they decrease with an increase in mastitis intensity because their synthesis is reduced. Total solids in milk were not statistically different between healthy and mastitis animals (**Table 1**) whereas between breeds differences were significant in healthy animals where PESA showed lower total solids in milk (**Table 2**). PE showed no differences in total solids in milk across different levels of SCC like as [24] found in a study to determine the influence of somatic cell count on the ewe's milk composition, cheese yield and cheese quality whereas [25] reported lower total solids in milk with an increase in SCC in ewes while PESA showed increased total solids in milk. In PE, protein content showed an increasing pattern from healthy animals to mastitis 1 and subsequently declined in mastitis 2 whereas in PESA it showed an increasing pattern while related literature reports a decreasing pattern [23,8]. Salt (Na and Cl) content in PE showed an increasing pattern from healthy animals to mastitis 1 and subsequently declined in mastitis 2 whereas in PESA it showed an increasing pattern with mastitis intensity. The increase in salt (Na and Cl) content is due to leakage from the blood [23].

In dairy cows, elevated SCC are always associated with mastitis [26], however in dairy goats SCC alone cannot be indicative of mastitis [6,8] since SCC gets elevated as lactation progresses. This research found that there is a significant difference in SCC and SCS between healthy and mastitis animals while other factors are not statistically different (**Table 1**). These results are consistent with that of [8] in that only SCC was different between healthy and mastitis goats while quality parameters like fat, protein, SNF, lactose and density did not differ significantly. However, in contrary to these findings, [23] indicated that lactose and protein content decline with an increase in SCC while salts tend to increase with elevated SCC.

Conclusions

This study concludes that, in dairy goats high SCC does not always reflect mastitis. Animals with elevated SCC should be declared mastitis positive after successful isolation and identification of mastitis causing bacteria. High SCC scores correlates negatively with milk quality.

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