

Research Application Summary

Factors influencing milk quality standards of dairy cows in Ghana

Coffie, I.^{1*}, Kanya-Agyemang, J.K.¹, Annor, S.Y.¹ & Annan-Prah, A²

¹Department of Animal Science Education, Faculty of Agriculture Education, University of Education, Winneba, P.O. Box 40, Mampong-Ashanti.

²Department of Animal Science, University of Cape Coast, University Post Office, Cape Coast.

***Corresponding author:** ismailcoffie@gmail.com

Abstract

This study was conducted to determine factors influencing quality standards of milk in dairy cows (Friesian-Sanga crossbred, Sanga and Jersey cows) in Ashanti, Eastern and Greater Accra regions of Ghana from February, 2017 to March, 2018. Lactometer, pH meter, haemocytometer, and standard plate count were used for milk quality assessment. Data on milk temperature, pH, specific gravity, somatic cells, and bacterial counts were subjected to analysis of variance (ANOVA) of SPSS, version 25. The overall means for raw milk temperature, pH and specific gravity among the dairy cows were 2.6 ± 0.43 , 6.5 ± 0.03 and 1.026 ± 0.00 . All the fixed factors had little effect on raw milk temperature and specific gravity. However, Jersey and Sanga cows had higher pH values as compared with Friesian-Sanga cow. Milk somatic cell count (MSCC) yielded an overall mean of was 134000 ± 7498.7 cells/mL. Jersey cows had the highest ($P < 0.01$) MSCC followed by Friesian-Sanga crossbred cows. Sanga recorded the lowest ($P < 0.01$) MSCC. The MSCC increased ($P < 0.01$) with increasing parity from 1 to 3. The overall Total Bacterial Count (TBC) was $3.0 \times 10^6 \pm 7.4 \times 10^5$. Ashanti region had the highest TBC while Eastern Region recorded the least count. Cows kept in good sanitary premises had the least ($P < 0.01$) TBC and vice versa. The overall means for Total coliform Count (TCC) was $2.9 \times 10^4 \pm 1.4 \times 10^4$. Geographical location, sanitary management, breed, and stage of lactation had great ($P < 0.01$) effect of TCC (Total Coliform Count). It is concluded that the low milk quality could be improved when milking is done in a cleaned and sanitized premises together with udder cleaning, hand washing with clean running water and mopping udder and hands prior to milking.

Key words: Ghana, microbial load, milk quality, sanitary practices, somatic cells count

Résumé

Cette étude était menée pour déterminer les facteurs influençant les normes de qualité du lait chez les vaches laitières (vaches croisées Friesian-Sanga, Sanga et Jersey) dans les régions d'Ashanti, de l'Est et du Grand Accra au Ghana de février 2017 à mars 2018. La qualité du lait était évaluée à l'aide du lactomètre, le pH-mètre, l'hémocytomètre et la méthode de numération sur plaque normalisée. Les données sur la température du lait, le pH, la densité spécifique, les cellules somatiques et le nombre de bactéries ont été soumises à l'analyse de variance (ANOVA) dans SPSS, version 25. Les moyennes globales de la température du lait cru, du

pH et de la densité chez les vaches laitières étaient de $2,6 \pm 0,43$, $6,5 \pm 0,03$ et $1,026 \pm 0,00$. Tous les facteurs fixés avaient peu d'effet sur la température et la gravité spécifique du lait cru. Cependant, les vaches Jersey et Sanga avaient des valeurs de pH plus élevées que les vaches Friesian-Sanga. Le comptage des cellules somatiques du lait (MSCC) a donné une moyenne globale de $134\,000 \pm 7\,498,7$ cellules/mL. Les vaches Jersey avaient le MSCC le plus élevé ($P < 0,01$), suivies des vaches croisées Friesian-Sanga. Sanga a enregistré le MSCC le plus bas ($P < 0,01$). Le MSCC a augmenté ($P < 0,01$) avec avec parité croissante de 1 à 3. Le nombre total de bactéries (TBC) global était de $3,0 \times 10^6 \pm 7,4 \times 10^5$. La région d'Ashanti avait le TBC le plus élevé tandis que la région de l'Est a enregistré le nombre le plus bas. Les vaches maintenues dans des locaux propres avaient enregistré moins de TBC ($P < 0,01$) et vice versa. La moyenne globale du nombre total de coliformes (TCC) était de $2,9 \times 10^4 \pm 1,4 \times 10^4$. La localisation géographique, la gestion sanitaire, la race et le stade de lactation ont eu un effet important ($P < 0,01$) sur le TCC (nombre total de coliformes). Il a été conclu que la faible qualité du lait pourrait être améliorée lorsque la traite est effectuée dans des locaux nettoyés et désinfectés, le nettoyage et essuyage de la mamelle et des mains devraient être faites à l'eau courante propre avant la traite.

Mots clés : Ghana, charge microbienne, qualité du lait, pratiques sanitaires, nombre de cellules somatiques

Introduction

Somatic cell count (SCC) determines the total number of cells per milliliter (mL) in milk. Somatic cells count SCC in raw milk comprises of leukocytes, or white blood cells, that are produced by the cow's immune system to fight an inflammation in the mammary gland, or mastitis (Kelci *et al.*, 2017). Somatic cell count is higher in poorly managed cows, mastitis problem, unhygienic milking and poor milk handling conditions (Dehinenet *et al.*, 2013). Somatic cell count increases with decreasing milk yield (Kelci *et al.*, 2017) usually resulting from poor nutrition.

Poor milk handling leads to high risk of illnesses from food-borne pathogens which are mainly from bacteria sources (Wanjala *et al.*, 2018). The main sources of bacterial contamination of raw milk emanate from within the udder, outside the udder, and from the surface of equipment used for milk handling and storage (Wallace, 2008). The bacteriological quality of raw milk, therefore, justifies the contamination of milk with bacterial organisms at different stages of the value chain (Reda *et al.*, 2014). Total coliform count is meant for bacteria that are most frequently associated with faecal/manure or environmental contamination such as bedding, soil, water, unhygienic handling and/or inadequate cooling of milk. Data on milk quality standards are crucial for health and safety assurance for both dairy cows and consumers of milk and its product. This study was conducted to evaluate effect of breed and non-genetic factors on fresh/raw milk's temperature, pH and specific gravity in dairy cows, and to determine effect of factors (genetic and non-genetic) influencing somatic cell count, total bacteria (viable) count, and total coliform count in milk of dairy cows in the study area.

Material and methods

This study was conducted in Ashanti, Eastern and Greater Accra regions of Ghana from February, 2017 to March, 2018. A total of 30 dairy cows (Friesian-Sanga crossbred, $n=10$; Sanga, $n=10$; and Jersey cows, $n=20$) were used for the study. Factors assessed included effect of location of farm, breed, parity, body condition score (1 – 5 scale), stage of lactation feed supplementation,

season of calving and sanitary management.

Measurement of specific gravity of milk by Lactometer. A lactometer (Giscom, India) is a hydrometer used to test milk purity. Quevenne is an arbitrary scale used with hydrometers or lactometers in the determination of the specific gravity of milk. Degrees Quevenne = 1000 (specific gravity $\approx$ 1). The specific gravity of milk was determined one hour after the milk was drawn from the cows in order to avoid a lower than normal value. Hence milk samples were kept in air conditioned environment in order to achieve the temperature of 20 °C or close. Fresh milk sample was poured into 200 mL measuring cylinder to about 8/9 full. Lactometer was then gradually lowered into the milk and allowed to float freely until equilibrium was reached. Lactometer reading was taken at the lower meniscus and recorded (as Quevenne's degree/lactometer degree—°L). The specific gravity of milk was calculated by dividing the Quevenne's degree by 1,000 and adding 1.

$$\text{Thus: Specific gravity (g/mL)} = \left(\frac{\text{lactometer degree} - ^\circ\text{L}}{1000} \right) + 1$$

The lactometer reading was standardized at a temperature of 20 °C (Gachuri *et al.*, 2012). The lactometer reading was corrected by adding 0.2 to the lactometer reading or 0.0002 to the specific gravity for each 1 °C above 20 °C and vice versa for lower temperatures (by subtracting when temperature fell below 20 °C).

Measurement of milk temperature and pH. Temperature of fresh milk sample was determined on the field of sampling using digital thermometer (Ashford Instrument Ltd, Kent). Milk pH were determined in the 'ABC' laboratory (Commercial facility) using a digital pH meter—500X500 (Partech Scientific Instruments, Thane West, Indian) in accordance to manufacturer's instructions.

Determining somatic cell count in milk of cows. Freshly obtained milk samples were kept on ice packs and transported to the University of Education, Winneba, College of Agriculture Education laboratory (Mampong Campus) for determination of somatic cell count using haemocytometer (Superior Marienfeld, Germany) and by following guidelines for counting somatic cell count (SCC) in milk (Fitts and Murphy, 2004) with slight modification. Hundred microliters (100 μ L) of milk sample was dispensed into micro centrifuge tube using micro pipette (Oxford LP Benchmate, Japan) and 100 μ L of 0.4 % trypan stain (used for differentiation between live and dead cells) was added. 10 μ L of the the prepared sampled was loaded into two well chambers of the haemocytometer with cover slide. The loaded slide was mounted on Compound microscope (GT Vision, UK) and observed (1000 X) magnification. Four (4) corner squares and one (1) centre square were count. Cells touching top and left boundaries were counted whiles cells touching bottom and right boundaries were not counted. Calculations of counted cells are as follows:

$$\% \text{ of viable cells} = \frac{\text{number of Viable somatic cells}}{\text{total number of somatic cell}} \times 100$$

$$\text{Average number of cells/square} = \frac{\text{Viable somatic cell}}{5 \text{ squares}}$$

$$\text{Dilution factor} = \frac{\text{Final volume (milk + stain)} = 200\mu\text{m}}{\text{Volume of milk} = 100\mu\text{m}} = 2$$

$$\text{Concentration SSC} = \frac{\text{Average number of cells}}{\text{squares}} \times \text{dilution factor} \times 10^4$$

Thus, only the results on the concentration of SCC were presented and expressed as SCC/mL.

Total bacterial and coliform count. Sanitary management and milking practices were considered as a factor. Under sanitized management condition, milking was done in a cleaned and sanitized premises (milking yard/cubicle) together with udder cleaning, hand washing with clean running water and mopping udder and hands with a clean napkin prior to milking. Farmer who milked with partial cleaning and little or no cleaning were also noted. The total bacterial and coliform counts were determined by method described by Ogot *et al.* (2015). Briefly, milk samples were serially diluted in peptone water. From the tubes with dilutions of 10⁻¹ – 10⁻⁵, 1 mL was pipetted and inoculated in standard plate count agar using pour plate method. The plated sample was allowed to solidify and then incubated at 37°C for 48 hours. Negative control was done using plate count agar only. For coliform count the milk samples were shaken 25 times then diluted using the same dilution procedure used for standard plate count. The samples were inoculated on MacConnkey agar using the spread plate method. The plates were then incubated at 37°C for 36 hours. The number of colonies was recorded using a colony counter. Only the plates with 30-300 colonies were considered in calculating the colony forming units (CFU) per mL of sample (Ogot *et al.*, 2015).

The CFU/mL of sample was determined using the formula:

$$\text{CFU per mL of sample} = \frac{\text{number of colonies}}{(\text{amount plated} \times \text{dilution})} \quad (\text{CFU/mL}).$$

Statistical analysis

Data on milk pH, temperature, specific gravity, somatic cells, and bacterial counts were subjected to analysis of variance (ANOVA) of SPSS (2017), version 25 under the following model:

$$Y_{ijklmn} = \mu + B_i + C_j + L_k + M_l + P_m + S_n + X_o + e_{ijklmn}; \text{ Where:}$$

Y_{ijklmn} = Dependent variable/traits being measured; μ = population mean; B_i = effect of i^{th} breed of cattle, $i = 1, 2$, and 3 ; C_j = effect of j^{th} body condition $j = 1, 2$ and 3 ; L_k = effect of k^{th} location of the study, $k = 1, 2$ and 3 ; M_l = effect of l^{th} sanitary management, $l = 1, 2$ and 3 ; P_m = effect of m^{th} parity of dam, $m = 1, 2$ and 3 ; S_n = effect of n^{th} stage of lactation, $n = 1, 2$ and 3 ; X_o = effect of o^{th} feed supplementation, $o = 1, 2$ and 3 .

Results and discussion

Effect breed and non-gentic factors on milk temperature, pH and specific gravity. Effect of fixed factors on milk temperature, pH and specific gravity is presented in Table 1. The overall means for raw milk temperature, pH and specific gravity among the dairy cows were 2.6 ± 0.43 , 6.5 ± 0.03 and 1.026 ± 0.00 , respectively. Location, breed, parity, body condition, stage of lactation, feed supplementation and season of calving did not significantly affect milk temperature and specific gravity in raw milk (Table 1). On the contrary, breed, and stage of lactation had significant effect on pH. Jersey cow had significantly higher pH value which was similar to the value observed in Sanga cow's raw milk. Friesian-Sanga had the lowest pH (6.4 ± 0.06) which slightly fall below the normal range of pH between 6.5 – 6.7 in cows (O'Connor, 1995). The pH values higher than 6.7 indicating mastitic milk whereas values below pH of 6.5 indicate the presence of colostrum or bacterial deterioration. A pH lower than 6.5, therefore, indicates that considerable acid development has taken place which is normally due to bacterial activity (O'Connor, 1995).

Table 1. Effect of breed and non-genetic factors on milk temperature, pH and specific gravity of dairy in Ghana

Fixed Factors	N	Temperature	pH	Specific gravity*
Overall	30	25.6±0.43	6.5±0.03	1.029±0.00
Location¹		0.871	0.423	0.681
Ashanti Region	10	25.9±1.12	6.4±0.08	1.03±0.00
Eastern Region	10	25.4±0.48	6.5±0.04	1.03±0.00
Greater Accra	10	25.4±0.56	6.5±0.04	1.03±0.00
Breed¹		0.302	0.018	0.180
Sanga	10	24.9±2.33	6.4±0.06b	1.030±0.01
Friesian-Sanga Cross	10	26.5±0.90	6.5±0.05a	1.030±0.01
Jersey	10	25.3± 0.56	6.6±0.04a	1.029±0.00
Parity¹		0.083	0.261	0.082
1	10	25.1±0.59	6.4±0.03	1.028±0.00
2	10	24.37±1.00	6.5±0.08	1.029±0.00
3	10	26.9±0.41	6.6±0.05	1.028±0.00
Body Condition Score(BCS)¹		0.688	0.261	0.052
BCS 2.5	10	25.4±0.56	6.6±0.03	1.030±0.00
BCS 3.0	10	26.1±1.02	6.4±0.07	1.029±0.00
BCS 3.5	10	25.2±0.65	6.5±0.05	1.028±0.00
Stage of Lactation¹		0.302	0.018	0.180
1 – 30 days	10	25.3±0.56	6.6±0.04a	1.029±0.00
31 – 60 days	10	26.5±0.90	6.5±0.05a	1.029±0.00
Above 61 days	10	24.9±0.73	6.4±0.06b	1.028±0.00
Feed Supplementation¹		0.842	0.214	0.088
Regular	10	25.2±0.77	6.4±0.07	1.028±0.00
Occasional	10	25.8±0.98	6.5±0.05	1.028±0.00
No supplementation	10	25.7±0.50	6.6±0.03	1.030±0.00
Season of calving¹		0.532	0.214	0.088
Rainy season	10	24.9±0.71	6.4±0.07	1.028±0.00
Minor season	10	26.1±0.99	6.5±0.05	1.028±0.00
Dry season	10	25.7±0.50	6.6±0.03	1.030±0.00

1=P-value; *=Specific gravity of milk values were read to 3 decimal places due to technicality in reading and recording the values using lactometer; N=number of observation. a,b,c,d=Means bearing different superscript in the same column are significantly different.

Effect of fixed factors on milk somatic cell count. Location had little effect on raw milk somatic cell count (MSCC). Management with distinct sanitary practices had significant ($P<0.05$) influence on MSCC such that cows under range grazing with poor sanitary practice had the highest count with the those maintained under exclusive zero grazing/good sanitary environment recording the least ($P<0.05$) MSCC (Table 4.14). Cows kept in partial and exclusive zero grazing management had similar ($P>0.05$) MSCC. Milk somatic cell count (MSCC), which is a general indicator of the mammary gland health, subclinical mastitis and as a standard measure for determining the quality of stored raw milk was influenced by sanitary management of premises, breed of cows, parity of dam and stage of lactation. The overall mean for composite MSCC observed (134000 ± 7498.7 cells/mL) in this current study was higher than 100,000 cells/mL for uninfected cows, and fall below the optimum MSCC threshold set at 150,000 and 200,000 cells/mL (Petzer *et al.*, 2017).

The current result indicates that MSCC decreased with increasing levels of good sanitation. The worst MSCC of poor sanitary production area might have resulted from septic infections of udder and contaminations of milk. Similarly, Dehinenet *et al.* (2013) reported that MSCC count was higher in poorly managed cows, mastitic problem, unhygienic milking and poor milk handling conditions. According to Harmon (1994), elevated SCC and compositional changes are due to an inflammation of the mammary gland that results from the introduction and multiplication of pathogenic microorganisms in the mammary gland which is a complex series of events leading to reduced synthetic activity. Elevated SCC above 200,000 cells/mL is a clear indicator that an animal has experienced or is developing (or recovering from) an infection (Bradley and Green, 2005). Kelci *et al.* (2017) reiterated that, good sanitation, bedding for lactating cows, control of flies, correct milking procedures, hygienic milking equipment, and good nutrition in a given season/month of the year can reduce the level of MSCC.

Breed had significant influence on milk somatic cell count (MSCC). Jersey cows had the highest ($P < 0.01$) MSCC but the value was similar ($P > 0.05$) to the MSCC in Friesian-Sanga crossbred cows. Sanga recorded the lowest ($P < 0.01$) MSCC. The MSCC increased with increasing proportion of high milking potential among the breeds considered. The noted variation is as a result of differences in the breeds' ability to withstand the hot-humid weather condition in the study area, which is dependent on the innate physiology of individual cow (Bradley and Green, 2005), with different physiologic vitals (Gachuiri *et al.*, 2012). Jersey cows are less adapted and may experience more stress with respect to high temperature and humidity as compared with Sanga and their crossbred counterparts.

Increased MSCC with increasing parity was observed in the current study although parity two and three had similar ($p > 0.05$) MSCC. According to Bradley and Green (2005) increase in SCC in milk of multiparous cows may be often, but not exclusively, due to an increased likelihood of infection with age.

Stage of lactation influenced MSCC in that cows in early stage of lactation experienced highest count, followed by mid and late stage of lactation. This variation can be linked to the stress associated with labour and the period of negative energy balance in the first stage of lactation. Physiological stress normally increases SCC in the first two weeks after calving, usually at a minimum in second month of lactation and gradual increase in later lactation accentuates when an infection is present (Bradley and Green, 2005). Location and body condition score had little effect on MSCC.

Table 2. Mean $\pm$ SE for effect of fixed factors on somatic cell count, total bacterial and total coliform count

Factors	N	Somatic cell count	TBC/mL	TCC/mL
Unit		cells/mL	cfu/mL	cfu/mL
Overall	30	134000.0 $\pm$ 7498.7	3.0 x 10 ⁶ $\pm$ 7.4 x 10 ⁵	2.9x10 ⁴ $\pm$ 1.4x10 ⁴
Location¹		0.136	0.008	0.001
Ashanti Region	10	154000.0 $\pm$ 14621.4	5.6 x 10 ⁶ $\pm$ 2.0 x 10 ^{6a}	1.8x10 ⁴ $\pm$ 9.4x10 ^{3a}
Eastern Region	10	118000.0 $\pm$ 12454.3	1.2 x 10 ⁶ $\pm$ 2.3x10 ^{5b}	9.7x10 ² $\pm$ 5.6x10 ^{2b}
Greater Accra	10	130000.0 $\pm$ 10000.0	2.1 x 10 ⁶ $\pm$ 3.3 x 10 ^{5b}	6.7x10 ⁴ $\pm$ 4.0x10 ^{4c}
Sanitary Management¹		0.042	0.016	0.002
Poor sanitation (RG)	10	155000.0 $\pm$ 11838.6 ^a	4.7x10 ⁶ $\pm$ 1.7x10 ^{6a}	6.7x10 ⁴ $\pm$ 3.3x10 ^{4a}
Fairly good (ZG _p)	10	128000.0 $\pm$ 8537.5 ^{ab}	2.4x10 ⁶ $\pm$ 4.0x10 ^{5b}	5.7x10 ³ $\pm$ 1.8x10 ^{3b}
Very good (ZG _e)	10	110000.0 $\pm$ 15583.9 ^b	1.1x10 ⁶ $\pm$ 2.9x10 ^{5c}	9.7x10 ² $\pm$ 5.2x10 ^{2c}
Breed¹		0.005	0.604	0.042
Sanga	10	112000.0 $\pm$ 6110.1 ^b	2.1x10 ⁶ $\pm$ 3.3 x 10 ⁵	6.2x10 ⁴ $\pm$ 3.9x10 ^{4a}
Friesian-Sanga	10	124000.0 $\pm$ 15434.4 ^{ab}	2.9x10 ⁶ $\pm$ 1.1 x 10 ⁶	1.2x10 ⁴ $\pm$ 9.8x10 ^{3b}
Jersey	10	166000.0 $\pm$ 9451.6 ^a	4.0x10 ⁶ $\pm$ 1.9x10 ⁶	1.1x10 ⁴ $\pm$ 7.4x10 ^{3b}
Parity¹		0.000	0.138	0.428
1	10	96000.0 $\pm$ 4988.9 ^b	1.8x10 ⁶ $\pm$ 3.6x10 ⁵	5.3x10 ⁴ $\pm$ 4.1x10 ⁴
2	10	146000.0 $\pm$ 12666.7 ^a	2.1x10 ⁶ $\pm$ 3.7x10 ⁵	7.4x10 ³ $\pm$ 2.3x10 ³
3	10	160000.0 $\pm$ 10328.0 ^a	5.1x10 ⁶ $\pm$ 2.1x10 ⁶	2.7x10 ⁴ $\pm$ 1.1x10 ⁴
Body Condition Score(BCS*)¹		0.748	0.505	0.438
BCS 2.5	10	128000.0 $\pm$ 12063.9	3.3x10 ⁶ $\pm$ 1.1x10 ⁶	3.5x10 ⁴ $\pm$ 1.3x10 ⁴
BCS 3.0	10	142000.0 $\pm$ 15040.7	1.8x10 ⁶ $\pm$ 4.7x10 ⁵	1.1x10 ³ $\pm$ 1.5x10 ³
BCS 3.5	10	132000.0 $\pm$ 11623.7	3.9x10 ⁶ $\pm$ 1.9x10 ⁶	4.8x10 ⁴ $\pm$ 4.0x10 ⁴
Stage of Lactation¹		0.005	0.604	0.042
1 (1 – 30 days)	10	166000.0 $\pm$ 9451.6 ^a	4.0x10 ⁶ $\pm$ 1.9x10 ⁶	1.1x10 ⁴ $\pm$ 7.4x10 ^{3b}
2 (31 – 60 days)	10	124000.0 $\pm$ 15434.4 ^b	2.9x10 ⁶ $\pm$ 1.1x10 ⁶	1.3x10 ⁴ $\pm$ 9.8x10 ^{3b}
3 (61 days and above)	10	112000.0 $\pm$ 6110.1 ^b	2.1x10 ⁶ $\pm$ 3.3x10 ⁵	6.3x10 ⁴ $\pm$ 4.0x10 ^{4a}

¹=P-value; N=Number of observation; RG =Range grazing; ZG_p = Partial zero grazing; ZG_e = Exclusive zero grazing; BCS*=Body condition score (1-5 scale); SCC=Somatic cell count; TBC=Total bacterial count; TCC=Total coliform count; ZG=Zero grazing; a,b,c,d=Means bearing different superscript in the same column are significantly different.

Effect of fixed factors on total bacteria count in milk. Effect of fixed factors on milk total viable or bacterial count (TBC) is also presented in Table 2. Location influenced ($P < 0.01$) TBC. Samples taken from Ashanti Region had the highest TBC while samples from Eastern Region recorded the least count. Farms located in the Ashanti region and Greater Accra had similar ($P > 0.05$) TBC. The higher TBC observed in farms of Ashanti and Greater Accra regions might be attributed to dominant management of dairy herds on range and partial zero grazing regimes with minimum level of biosecurity practices, especially, on sanitation, as compared with farms in the Eastern region with fair to good observation of hygienic standards. Otherwise, the farms in the Ashanti and Eastern regions lie in the hot-humid environment with more secondary and inciting factors of diseases might have experience higher count. The implication is that good management with good sanitation, proper handling of milk and its equipment can offset or reduce environmental impact on contaminations emanating from sepsis. The main sources of bacterial contamination of raw milk emanate from within the udder, outside the udder, and from the surface of equipment used for milk handling and storage (Wallace, 2008). The

bacteriological quality of raw milk, therefore, justifies the contamination of milk with bacterial organisms at different stages of the value chain (Reda *et al.*, 2014). Means of TBC observed in the current findings (Table 2.) were higher than the bacterial count limit for the EU (1.0×10^5 cells/mL) (Centres for Epidemiology and Animal Health—CEAH, 2014; Reda *et al.*, 2014). By standards, the overall mean TBC ($3.0 \times 10^6 \pm 7.4 \times 10^5$ or 6.3 ± 0.07 cells/mL) in current findings can be graded fair since the count is between 1×10^6 and 5×10^6 CFU/mL of milk. Whereas TBC exceeding 5×10^6 CFU/mL (as observed in farms of Ashanti region) is graded as poor quality (Reda *et al.*, 2014). Effect of breed, parity, BCS, and stage of lactation were not good determinants of TBC in raw milk in this study.

Sanitary management had significant ($P < 0.05$) effect on TBC in raw milk. Cows kept in good sanitary premises had the least TBC whereas cows under poor/fair management had similar ($P > 0.05$) TBC but the values were significantly ($P < 0.05$) higher than those observed in good sanitary environment. Breed, parity, BCS, and stage of lactation did not significantly ($P > 0.05$) influence TBC in this study.

Effect of fixed factors on total coliform count in milk. Effect of location, sanitary management, breed, parity, BCS, and stage of lactation on raw milk total coliform count (TCC) is presented in Table 2. Location had a significant ($P < 0.01$) effect on TCC. Ashanti region recorded the highest ($P < 0.01$) TCC, followed by Eastern and Greater Accra Regions in descending order. The acceptable level of total coliform counts in raw milk has been set as $< 10^3$ CFU/mL in Kenya, and grade 'A' raw milk has $< 10^3$ CFU/mL for the total coliforms in (Gachui *et al.*, 2012). The current study recorded higher value of TCC (2.9×10^4) than the acceptable European Union (EU) limit of $< 1.0 \times 10^2$ CFU/mL for coliform counts in raw milk but fell within the range reported for TCC in milk samples in Zimbabwe (Wanjala *et al.*, 2018). The significant effect of location, sanitary management practices, breed and stages of lactation on TCC in milk can be attributed to compromise of sanitation, personal hygiene and milking equipment. The presence of high TCC indicates poor milking hygiene originating in environmental contamination such as bedding, soil, poor water, faeces, inadequate cooling of milk (Wallace, 2008).

Conclusion

All the fixed factors had little effect on raw milk temperature and specific gravity. However, Jersey and Sanga cows had higher pH value as compared with Friesian-Sanga cow. Jersey cows had the highest Milk somatic cell count (MSCC) followed by Friesian-Sanga crossbred cows and Sanga in descending order. MSCC increased with increasing parity. The MSCC greatly decreased with increasing stage of lactation. Location and sanitary management had effect on total bacterial count. Different geographical location with varied farm practices, sanitary management, breed, and stage of lactation had great effect of total coliform count.

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