EFFECTS OF BREEDS OF COWS AND NON-GENETIC FACTORS ON MILK PRODUCTION AND NUTRIENT COMPOSITION

Deku, G.,[1*] Antwi, C.,[1] Karikari, P.K.,[1] Okai, D.B.,[1] Omojola, A.B.[2]
[1]*Department of Animal Science*
Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
[2]*Department of Animal Science, University of Ibadan, Ibadan Nigeria*
**Corresponding author's Email Address: gyaw.deku@gmail.com*
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ABSTRACT
A study was conducted in the Ejisu/Juaben Municipality of the Ashanti region of Ghana, on different breeds of lactating cows to analyze their milk yield and nutrient composition. A total of a one hundred and thirty-three (133) lactating cows consisting of 6 local breeds found within 24 farms in the municipality were grouped into seven blocks for the study. Milk samples were taken fortnightly from the first month to the eighth month of lactation. The milk samples were transported on ice to the KNUST Dairy Science Laboratory for analyses. Milk samples were collected fortnightly at the beginning of each month during the study period and measured by weighing the milk from each lactating cow with an electronic weighing scale. The data collected were subjected to statistical analysis using Minitab version 18 (2017). Total solid in milk was significantly ($p < 0.05$) higher in the rainy season (13.64 %) than in the dry season (13.12 %). The West African Short horn cows recorded the least milk yield of 447.78g per day. Gudali cows recorded the highest daily milk yield per cow (2214.60 g) but it was similar to the 1898.82 g produced by Humped crosses (Zebu crosses). Nutrient composition of the milk produced in the Ejisu/Juaben Municipality was not influenced by the breed of cows except for total solids and milk fat yield. Gudali cows had the highest daily milk fat yield of 120.63 g whilst the least fat yield was recorded for WASH cows (32.69 g). The study showed that Gudali cows and Humped crosses (Zebu crosses) could be selected for milk production. It was recommended that herdsmen and cattle owners be trained in record keeping and selection of high performing cows.

Keywords: *Local breeds, Farm Survey, Daily Milk Yield, Lactation Stage, Milk Composition, Seasonal Variation*

INTRODUCTION
Most of the cattle farmers in Ghana raise local breeds of cattle. The local breeds are mainly beef cattle or dual-purpose cattle. Both beef and dual-purpose cows are low milk yielding cows (Mpofu, 1993). It has been reported that West Africa as a continent produces the least amount of milk in the entire Sub-Saharan Africa. The low output in the dairy sector in Ghana is probably due to the breeds of cattle used for milk production as against Aryshire, Holstein-Friesian, Brown Swiss and Jersey cows that are for milk production in other parts of Sub- Saharan Africa (Opoola *et al*., 2019). Unfortunately, the cattle farmers in the Ejisu/Juaben Municipality of Ghana rely heavily on the beef/dual purpose

cows to produce milk for sale, the proceeds of which are usually used as part of remuneration given to herdsmen.

Apart from the low milk yield of the local breeds of cows in the Municipality, they are also reported to have a short length of lactation (Seck *et al*., 2016) that reduces the total milk yield obtained from the various breeds of cattle for sales.

It has been reported by Maharana and Mishra (2020) that milk produced by cows vary in nutrient composition and it is seen especially in local breeds where much improvement has not been made. Works of others (Okantah, 2009) reported that one of the ways to improve milk yield and production in Africa is to do selection among our own locally available breeds of cattle which have adapted to the harsh environmental conditions. However, an effective selection can only be done if there are reliable data on the locally available breeds of cows (Missanjo, 2010) in the country. Based on reliable data, suggestions can be made on crosses of local breeds that can be used for milk production in Ghana (MOFA, 2004). Although a lot of studies have been done on the effect of breeds and non-genetic factors on milk production of these local breeds (Coffie *et al*., 2015), there is a dearth in information on the nutrient composition of milk produced by these local breeds of cattle in Ghana. Studies confirm that breeds of cattle play a leading role among the factors that affect composition of milk produced by a cow (Abubakar *et al*. 2023). Aside the knowledge of the nutritional composition of milk produced, it has also become necessary to catalogue the nutrient composition of milk produced within these areas of milk production in Ghana so as to monitor the issue of milk adulteration observed at the milk collection centres and processing units.

The study was therefore set up to assess the effect of breed and non-genetic factors like stage of lactation on the yield and nutrient composition of milk produced in the Ejisu/Juaben Municipality of Ghana.

MATERIALS AND METHODS

Study area

The study was conducted in the Ejisu/Juaben Municipality of the Ashanti region of Ghana. The area falls within the semi-deciduous forest ecological zone and experiences a bimodal rainfall. The rainy seasons are April to July and September to November. There is a short dryness in August but the main dry season starts from December and ends in March (Coffie *et al*., 2015). The mean annual rainfall is 1300 mm and the average daily temperature is about 27^{o}C.

Experimental design

A longitudinal survey design (Lynn, 2009; Coffie *et al*., 2015) was used to obtain data on the effect of breeds and stage of lactation on milk production and nutrient composition of milk in the Ejisu/Juaben Municipality. A total of twenty-four (24) farms were used for the study and were put into seven (7) blocks according to locality and proximity of the communities in which the lactating cows were found. Farms in some blocks were closer to each other while farms in other blocks were far apart. The following are the farm blocks with their respective number of farms in brackets; Ampabame, (3); Bomfa, (6); Essienimpong (3); Krapa (3); Odaho (4); Besease (3) and Duapompo, (2). These breeds of cows (Gudali, N'dama, Sanga, Humpless Crosses (indigenous taurine), Humped Crosses (indigenous taurine) and WASH (West African Shorthorn)) were tested over the two (2) major seasons (i.e., rainy and dry) in Ghana for their effect on milk yield, nutrient composition and physicochemical properties of milk.

Data collection

Data was collected on milk yield, nutrient composition and the physicochemical properties of milk produced by the breeds of cows during 8 months of lactation over the two major seasons in Ghana. A total of hundred and thirty-three (133) lactating cows consisting of Gudali (9), N'dama (7), Sanga (42), Humpless crosses (34), Humped crosses (35), WASH (6) were used for the experiment as milk samples were taken from them in the various farms.

Milk sampling

Data on daily milk yield was collected fortnightly from the first month of lactation to the eighth month of lactation during the survey**.** The collected milk was weighed with an electronic scale (SF 400) and the quantity recorded. Daily milk yield (S) was estimated using the formula S=M +0.6596M as reported by Udo *et al.* (2020) for the farms as they practised once-a-day milking. The M in the equation is the milk yield recorded in the morning.

Biochemical /nutrient composition analysis of milk

Two hundred and fifty millilitres (250 ml) of milk was sampled into a sterilized glass bottle and transported on ice to the Dairy Science Laboratory at Dairy/Beef Cattle Research Station, KNUST Kumasi. The sample was assayed for protein, fat, solid not fat, total solids, lactose, pH, milk density, milk conductivity and freezing point using Lactoscan Milk Analyser (Milkotronic Limited, Bulgaria).

Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) using Minitab version 18 (2017). All tests were done at 5% level of significance and the means (± SE) were separated using Bonferroni pair comparison.

RESULTS

Effect of breed on milk yield and nutrient composition

The mean values obtained for milk yield showed a significant difference (p<0.001) among the breeds of cows (Table 1). It was observed in the study that the West African Short horn cows recorded the least daily milk yield (447.78 g) whilst Gudali breed of cows recorded the highest daily milk yield (2214.60 g) which was statistically similar to the 1898.82 g produced by Humped crosses. Daily milk yield per cow recorded for the Humpless cross cows, Sanga cows, N'dama cows and WASH cows (Table 1) were also similar. However, the nutrient composition of the milk produced in the Ejisu/Juaben Munici-

Table 1: Daily Milk Yield (± SE) and Composition of Milk (± SE) Produced by Different Breeds of Lactating Cows in the First 8 months of Lactation

Breed	Morning Milk Yield (g/cow/day)	Estimated Daily Milk Yield (g/cow/day)	Fat (%)	Protein (%)	SNF (%)	Total Solids (%)	Lactose (%)	Calculated Milk Fat Yield (g/d)	Calculated Milk Energy (Cal/100g)
Humpless Crosses	1405.17±37.10b	2332.01±61.60b	4.63±0.17	3.04±0.01	8.31±0.2	13.22±0.12b	4.58±0.01	68.05±3.72b	72.19±1.45
Gudali	2214.60±140.00a	3675.35±233.00a	5.32±0.28	3.08±0.02	8.40±0.05	13.91±0.28ab	4.63±0.03	120.63±10.40a	78.71±2.50
N'dama	1223.62±70.30b	2030.73±117.00b	4.92±0.24	3.01±0.04	8.23±0.10	13.64±0.26ab	4.53±0.06	58.41±4.10bc	74.78±2.10
Sanga	1314.13±33.50b	2180.93±55.60b	4.85±0.10	3.06±0.01	8.35±0.02	13.67±0.09ab	4.60±0.01	65.43±2.40b	74.24±0.84
Humped Crosses	1898.82±64.10a	3151.28±106.00a	5.15±0.09	3.03±0.01	8.27±0.02	13.79±0.10a	4.56±0.01	98.04±3.90ab	76.68±0.81
WASH	447.78±66.90b	743.13±111.00b	6.14±1.77	3.11±0.07	8.48±0.18	14.07±0.92ab	4.68±0.10	32.69±9.35c	86.37±16.1
P value	< 0.001	< 0.001	0.20	0.14	0.13	0.02	0.99	<0.001	0.16

Means that do not share a letter in the same column are significantly different (P< 0.05). Where there are no letters in a column the means are statistically the same.± SE = Standard Error pality was not influenced (p>0.05) by the breed of cows except for total solids and milk fat yield which was significantly different (p<0.001) nevertheless Gudali cows had the highest milk fat yield of 120.63 g/d among the breeds with WASH cows recording the least fat yield (32.69 g/d).

Milk yield, protein percentage, solids non-fat and lactose content of milk produced within the first 8 months of lactation in the various farm blocks showed significant ($p < 0.05$) differences among the breeds of the lactating cows (Table 2).

Daily milk yield and nutrient composition of milk in the Ejisu/Juaben Municipality were similar between the farm blocks and their interaction with the seasons except for the total solids content which was significantly different (Table 4 and 3).

From Table 5, the means of milk yield and nutrient composition did not show any significant differences ($p > 0.05$) for breeds and season interaction.

The interaction between farm blocks and seasons for daily milk yield and nutrient composition of milk produced within the first 8 months of lactation were not significantly different except for total solids (p=0.05). The highest total solid values (14.69 %) were recorded in the wet season in the Duapompo block and the least was 12.70 % recorded in the dry season in the Besease block (Table3).

Effect of stage of lactation on milk yield and nutrient composition

The stage of lactation influenced significantly ($p < 0.001$) milk fat, total solids and energy content of the milk produced in the Ejisu/Juaben Municipality (Table 6) but it did not have any significant ($p > 0.05$) effect on total milk fat yield, and milk yield.

The differences between the means for protein (p=0.06), SNF (p=0.07) and lactose (p=0.07) were observed to be approaching significance (Table 6). On the other hand, the highest milk fat

Table 2: Daily Milk Yield (± SE) and Nutritional Composition (± SE) of Milk Produced by Lactating Cows in The First 8 months Weeks of Lactation

Farm Block	Morning Milk Yield (g/cow/day)	Estimated Daily Milk Yield (g)	Fat (%)	Protein (%)	SNF (%)	Total Solids (%)	Lactose (%)	Calculated Milk Fat Yield (g/d)	Calculated Milk Energy (Cal/100g)
Ampabame	1687.66±99.60a	2800.84±165.00a	5.17±0.17	3.04±0.01ab	8.31±0.04ab	13.61±0.19	4.58±0.02ab	85.28±5.89	77.00±1.46
Essienimpong	1300.11±80.40ab	2157.66±134.00ab	5.17±0.27	3.09±0.02a	8.44±0.05a	13.87±0.26	4.65±0.03a	68.88±6.73	77.51±2.34
Bomfa	1303.70±44.00b	2163.61±73.10b	5.48±0.27	3.04±0.01ab	8.31±0.03ab	13.70±0.17	4.58±0.02ab	74.52±5.78	79.82±2.31
Krapa	1506.62±53.60ab	2500.39±89.00ab	4.94±0.12	3.05±0.01ab	8.33±0.02ab	13.49±0.13	4.59±0.01ab	72.72±3.60	75.07±1.10
Odaho	1565.88±73.00ab	2598.73±121.00ab	5.35±0.10	3.07±0.01a	8.40±0.03a	13.93±0.10	4.63±0.01a	85.08±4.48	78.94±0.89
Besease	1414.69±42.70ab	2347.82±70.80ab	5.02±0.11	3.01±0.01b	8.21±0.03b	13.45±0.11	4.52±0.02b	71.02±2.67	75.27±0.98
Duapompo	1142.82±45.30b	1896.63±75.20b	5.04±0.23	3.07±0.02ab	8.39±0.05ab	13.95±0.26	4.62±0.02ab	59.61±3.53	76.16±2.01
P value	0.001	0.001	0.36	<0.001	<0.001	0.13	<0.001	0.08	0.24

Means that do not share a letter in the same column are significantly different ($p < 0.05$) and those that do not have letters are similar. ± SE = Standard Error

Table 3: Effect of Farm Block X Season Interaction on Daily Milk (± SE) Yield and composition of milk (± SE) Produced by cows in the first 8 months of lactation

Farm Block X Season	Morning Milk Yield (g)	Estimated Daily Milk Yield (g)	Fat (%)	Protein (%)	SNF (%)	Total Solids (%)	Lactose (%)	Calculated Milk Fat Yield (g/d)	Milk Energy (Cal/100g)
Odaho x Wet	1602.15±136.00	2658.92±227.00	5.77±0.19	3.09±0.01	8.44±0.04	14.44±0.17a	4.65±0.02	91.30±8.67	82.88±1.63
Essienimpong x Wet	1376.24±144.00	2282.28±240.00	4.94±0.21	3.09±0.02	8.43±0.06	13.79±0.32ab	4.64±0.03	65.36±7.21	75.39±1.82
Duapompo x Wet	1248.51±70.70	2072.02±117.00	5.30±0.31	3.08±0.02	8.43±0.06	14.69±0.53ab	4.64±0.03	65.02±6.34	78.64±2.69
Essienimpong x Dry	1223.97±93.50	2031.31±155.00	5.41±0.38	3.09±0.02	8.45±0.07	13.96±0.36a	4.65±0.04	72.40±9.62	79.63±3.37
Krapa x Wet	1638.04±106.00	2718.49±177.00	5.29±0.22	3.06±0.01	8.36±0.04	14.02±0.27ab	4.61±0.02	80.77±7.25	78.27±2.00
Odaho x Dry	1529.61±86.20	2538.54±143.00	4.93±0.12	3.06±0.01	8.36±0.03	13.42±0.12ab	4.61±0.02	78.85±5.20	75.00±1.05
Duapompo x Dry	1037.14±49.40	1721.24±82.00	4.79±0.30	3.06±0.02	8.35±0.06	13.22±0.26ab	4.60±0.03	54.21±3.99	73.68±2.53
Ampabame x Wet	1687.44±182.00	2800.48±302.00	5.48±0.20	3.05±0.02	8.35±0.05	14.08±0.31ab	4.60±0.03	84.54±8.39	79.88±1.71
Bomfa x Dry	1357.86±52.00	2253.51±86.20	5.04±0.24	3.05±0.01	8.32±0.04	13.39±0.22ab	4.58±0.02	72.90±4.71	75.90±2.08
Krapa x Dry	1375.20±59.50	2282.28±98.70	4.60±0.15	3.04±0.01	8.30±0.03	12.96±0.15ab	4.57±0.02	64.68±4.04	71.88±1.32
Bomfa x Wet	1249.53±83.60	2073.72±139.00	5.92±0.71	3.04±0.03	8.30±0.07	14.01±0.27ab	4.57±0.04	76.13±16.30	83.73±6.15
Ampabame x Dry	1687.87±117.00	2801.19±195.00	4.86±0.24	3.03±0.02	8.28±0.05	13.15±0.23ab	4.56±0.02	86.02±8.03	74.12±2.10
Besease x Wet	1400.34±81.10	2324.00±135.00	5.57±0.26	3.01±0.02	8.22±0.05	14.20±0.24ab	4.53±0.03	76.09±6.00	80.30±2.28
Besease x Dry	1429.05±49.80	23.7165±82.60	4.46±0.11	3.01±0.01	8.21±0.03	12.70±0.11b	4.52±0.10	65.94±2.71	70.24±0.97
P value	0.53	0.53	0.29	0.95	0.94	0.05	0.93	0.87	0.24

Means that do not share a letter in the same column are significantly different. (P< 0.05) ± SE = Standard Error

Table 4: Daily Mean Yield (± SE) and nutrient composition of milk (± SE) produced by lactating cows in the first 8 months of lactation in the wet and dry seasons

Season	Morning Milk Yield (g)	Estimated Daily Milk Yield (g)	Fat (%)	Protein (%)	SNF (%)	Total Solids (%)	Lactose (%)	Calculated Milk fat yield (g/d)	Milk Energy (Cal/100 g)
Dry	1377.24±31.00	2285.67±51.50	4.87±0.07	3.05±0.01	8.32±0.02	13.26±0.07b	4.58±0.01	70.71±2.10	74.35±0.65
Wet	1457.46±50.90	2418.81±84.40	5.47±0.15	3.06±0.01	8.36±0.02	14.18±0.10a	4.61±0.01	77.03±4.12	79.87±1.29
P value	0.64	0.64	0.23	0.70	0.68	0.02	0.65	0.64	0.20

Means that do not share a letter in the same column are significantly different. (P< 0.05) ± SE = Standard Error

Table 5: Effect of Breed X Season Interaction on Daily Mean (± SE) Yield and Nutrient composition (± SE) of milk Produced by cows in the first 8 months of lactation on Farms in Ejisu/Juaben Municipality

Season X Breed Interaction	Morning Milk Yield (g)	Estimated Daily Milk Yield (g)	Fat (%)	Protein (%)	SNF (%)	Total Solids (%)	Lactose (%)	Calculated Milk Fat Yield (g)	Milk Energy (Cal/100 g)
Dry x Wash	502.40±0.00	833.79±0.00	4.19±0.00	3.16±0.00	8.61±0.00	12.89±0.00	4.74±0.00	24.92±0.00	69.29±0.00
Wet x Gudali	2117.61±288.00	3514.38±478.00	5.40±0.45	3.09±0.03	8.45±0.09	14.20±0.47	4.66±0.05	117.96±19.10	79.62±3.98
Wet x Sanga	1479.68±68.10	2455.67±113.00	4.88±0.17	3.08±0.01	8.40±0.04	14.15±0.15	4.63±0.02	73.82±4.79	74.77±1.45
Wet x Wash	393.15±113.00	652.47±187.00	8.09±1.77	3.06±0.10	8.36±0.28	15.25±0.55	4.61±0.16	40.45±3.73	103.46±17.00
Wet x Humpless crosses	1467.37±74.80	2435.24±124.00	4.53±0.41	3.06±0.02	8.36±0.05	13.38±0.21	4.60±0.03	70.47±9.76	71.46±3.60
Dry x Gudali	2311.60±162.00	3836.33±269.00	5.24±0.36	3.06±0.02	8.35±0.34	13.62±0.34	4.60±0.03	123.29±12.60	77.79±3.12
Wet x Humped crosses	2052.50±110.00	3406.33±182.00	4.95±0.15	3.04±0.01	8.31±0.03	13.93±0.19	4.58±0.02	101.09±6.84	75.01±1.35
Dry x Sanga	1148.59±36.90	1906.20±61.20	4.8±10.12	3.04±0.01	8.30±0.11	13.19±0.11	4.57±0.01	57.03±2.70	73.70±1.02
Wet x N'Dama	1234.48±104.00	2048.75±172.00	4.95±0.49	3.03±0.04	8.28±0.11	14.14±0.57	4.56±0.06	58.39±8.49	74.90±4.34
Dry x N'Dama	1212.77±90.60	2012.71±150.00	4.90±0.28	2.99±0.05	8.18±0.26	13.13±0.26	4.50±0.08	58.43±4.75	74.06±2.36
Dry x Humpless Crosses	1342.96±42.30	2228.78±70.30	4.73±0.16	3.03±0.01	8.26±0.15	13.06±0.15	4.55±0.01	65.62±3.35	72.91±1.40
Dry x Humped crosses	1746.70±77.80	2896.24±129.00	5.35±0.12	3.01±0.01	8.23±0.11	13.65±0.11	4.53±0.02	94.99±4.74	78.35±1.01
P value	0.31	0.31	0.50	0.99	0.99	0.28	0.99	0.84	0.48

percentage was recorded on the 8th month of lactation and the least was during the 1st month of lactation. Fat content of milk produced in the municipality increased from the first month to the sixth month. The percentage fat in the milk produced on the 6th month of lactation was significantly higher but dropped on the 7th month and shot up during the 8th month.

Total solids in the milk produced by lactating cows in the study area ranged from 12.92 % to 14.33 %. The lowest total solids of milk were produced in the 1st month and it was significantly ($p < 0.001$) lower than those produced from the 4th month to the 8th month. The total solids content of the milk increased from the 1st month to the 8th month with a slight decline from the 5th to 6th month and 7th to 8th month.

Calculated energy was lowest in the first month of lactation and highest in the eighth month of lactation. The energy in the milk samples increased from 1st month to 6th, dropped in the 7th month and increased again in the 8th month.

Figure 1 indicates the relationship between stage of lactation and milk yield. It shows that milk yield increases up to the second month before it declines and rises again. The milk yield drops again from the seventh month of lactation.

The link between stage of lactation (month) and total milk solids (%) has been shown in figure 2. The total solids of milk peaked at the seventh month.

Table 6: Daily Mean (± SE) Yield and composition of milk (± SE) Produced by cows within 8 months of lactation

Stage of Lactation (Month)	Morning Milk Yield (g)	Estimated Daily Milk Yield (g)	Fat (%)	Protein (%)	SNF (%)	Total Solids (%)	Lactose (%)	Calculated Milk Fat Yield (g/d)	Calculated Milk Energy (Cal/100 g)
1	1523.59±74.50	2528.54±124.00	4.48±0.16c	3.12±0.01	8.39±0.03	12.92±0.15b	4.62±0.02	67.88±5.06	71.10±1.36c
2	1592.02±58.60	2642.12±97.20	4.69±0.11bc	3.05±0.01	8.34±0.03	13.04±0.10b	4.59±0.01	73.50±3.43	72.76±0.94bc
3	1526.40±60.20	2533.21±99.80	4.93±0.12bc	3.05±0.01	8.34±0.03	13.49±0.12ab	4.60±0.01	74.89±3.86	75.01±1.06bc
4	1433.96±61.00	2379.79±101.00	5.21±0.12bc	3.04±0.01	8.29±0.03	13.78±0.13a	4.57±0.02	74.33±3.97	77.26±1.06bc
5	1473.46±71.20	2445.35±118.00	5.37±0.25ab	3.04±0.01	8.29±0.03	13.96±0.23a	4.57±0.02	79.66±5.53	78.79±2.17ab
6	1374.99±87.40	2281.93±145.00	5.68±0.47a	3.01±0.02	8.23±0.05	13.94±0.17a	4.53±0.03	80.43±11.80	81.33±4.07a
7	1331.61±125.00	2209.94±208.00	5.22±0.28bc	3.05±0.02	8.33±0.06	14.33±0.29a	4.59±0.03	72.11±8.66	77.56±2.39bc
8	1082.80±298.00	1797.02±494.00	5.76±0.47a	3.12±0.05	8.51±0.14	14.27±0.46ab	4.69±0.08	6817±21.30	83.08±3.92a
P value	0.16	0.16	< 0.001	0.06	0.07	< 0.001	0.07	0.80	< 0.001

Means that do not share a common letter in the same column are significantly different (P<0.05) and means that do not have letters in a column are similar.± SE = Standard Error

Effect of breed on the physicochemical properties of Milk

The pH, conductivity and freezing point of milk produced by the various breeds of cows within the first eight months showed significant ($P < 0.05$) differences in the farm blocks and for the breeds. From Table 7, pH for milk was observed between 6.66 and 6.78 for Farm blocks, 6.67 to 6.76 for breeds, 6.73 for dry season and 6.70 for wet season whilst 6.66 to 6.85 was observed for breed x season interactions (Table 8).

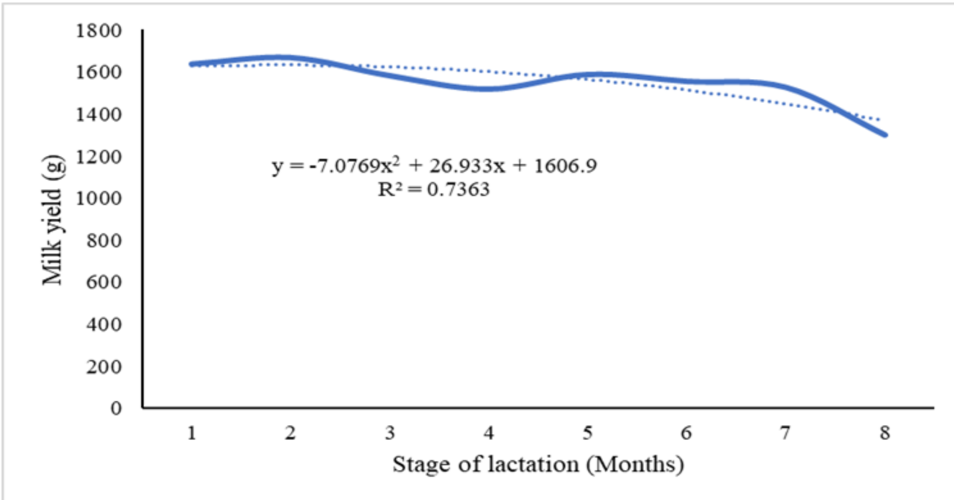
Milk conductivity results showed significant ($p < 0.001$) differences in milk produced on the various farms in Table 7 and for breeds (Table 7). However, conductivity for season and farm block interactions did not show significant differences but season and breed x season interaction values for conductivity were close to significance.

Milk freezing point results obtained for lactating cows on the various farms (Table 7) showed significant differences ($p < 0.001$) just as results for the various breeds (7) also showed significant differences ($p < 0.05$). Season, breed x season interaction and season x farm block interaction did not have any influence on milk freezing point (Tables 7 and 8).

The mean milk density results reported for farm blocks, breeds, seasons (Table 7), farm block x season interaction and breed x season interaction (Table 8) did not show significant ($P > 0.05$) differences.

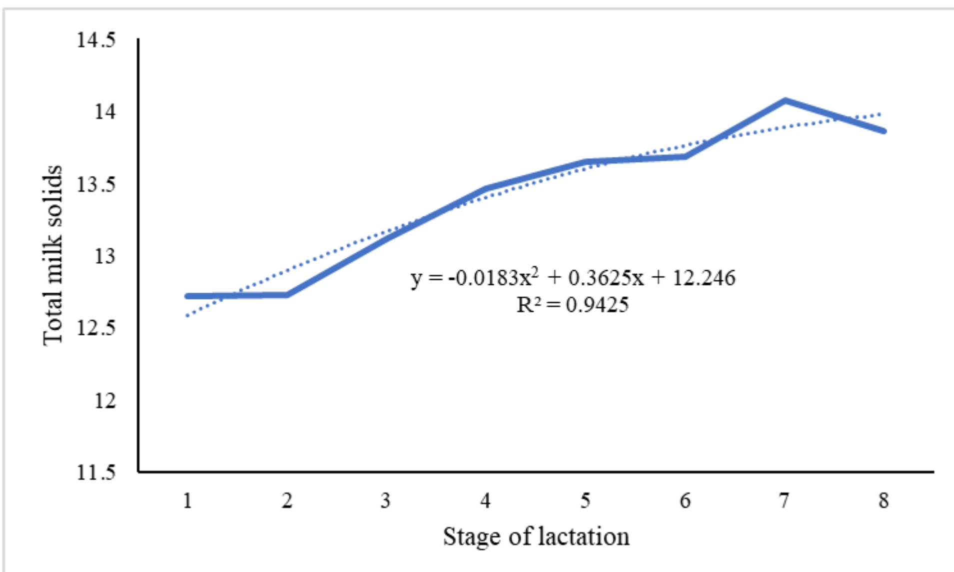
Stage of lactation and its effect on the physicochemical properties of Milk

Stage of lactation significantly influenced milk density, pH, and milk con-



.... **predicted pattern** ____**observed pattern**

Figure 1: Relationship between stage of lactation and milk yield predicted pattern observed pattern



.... predicted pattern ___**observed pattern**

Figure 2: Interaction between stage of lactation and total milk solids predicted pattern observed pattern

Table 7: Mean (± SE) Density, pH, Conductivity and Freezing Point of Milk Produced by Cows in the First 8 months of Lactation

Farm Block	Milk Density (kg/m^3)	pH	Milk Conductivity (mS/cm)	Milk Freezing Point (°C)
Ampabame	1028.19±0.22	6.74±0.012abc	3.39±0.06a	-0.54±0.002ab
Essienimpong	1028.73±0.33	6.66±0.014bc	3.24±0.06ab	-0.55±0.003b
Bomfa	1028.37±0.19	6.74±0.010a	3.21±0.03ab	-0.54±0.002ab
Krapa	1028.44±0.15	6.67±0.009b	3.19±0.03ab	-0.54±0.002ab
Odaho	1028.42±0.15	6.73±0.016ac	3.13±0.03b	-0.55±0.002b
Besease	1027.94±0.17	6.69±0.009abc	3.09±0.03b	-0.53±0.002a
Duapompo	1028.65±0.32	6.78±0.017a	3.08±0.06b	-0.54±0.003ab
P value	0.25	< 0.001	< 0.001	< 0.001
Breed				
Humpless Crosses	1028.89±0.13a	6.67±0.007b	3.22±0.027b	-0.54±0.001c
Gudali	1028.53±0.34ab	6.72±0.017ab	3.10±0.051c	-0.55±0.003b
N'dama	1027.78±0.49b	6.72±0.031ab	3.10±0.084c	-0.54±0.007c
Sanga	1028.67±0.14ab	6.71±0.007ab	3.06±0.022c	-0.54±0.001c
Humped Crosses	1028.19±0.13ab	6.72±0.015ab	3.22±0.028b	-0.54±0.002c
WASH	1028.29±1.51ab	6.76±0.059a	3.42±0.276a	-0.56±0.019a
P value	0.04	0.03	< 0.001	0.03
Season				
Dry	1028.57±0.09	6.73±0.005	3.27±0.02	-0.54±0.001
Wet	1028.22±0.13	6.70±0.013	3.10±0.03	-0.55±0.001
P value	0.52	0.49	0.08	0.26

Means that do not share a common letter in the same column are significantly different. (P < 0.05) and those that do not have letters in a column are not significantly (p>0.05) different. ± SE = Standard Error

Table 8: Effect of breed X Season Interaction on Mean (± SE) Density, pH, Conductivity and freezing Point of milk Produced by different breeds of cows in the first 8 months of lactation

Season X Breed Interaction	Milk Density (kg/m^3)	pH	Milk Conductivity (mS/cm)	Milk Freezing Point (°C)
Dry X WASH	1030.26±0.00	6.85±0.00	3.66±0.00	-0.55±0.00
Wet X Gudali	1028.63±0.55	6.76±0.03	3.00±0.10	-0.55±0.006
Wet X Sanga	1028.81±0.23	6.70±0.01	3.03±0.04	-0.54±0.002
Wet X WASH	1026.32±0.31	6.67±0.08	3.19±0.12	-0.56±0.033
Wet X Humped crosses	1028.54±0.20	6.74±0.04	3.26±0.05	-0.54±0.002
Dry X Gudali	1028.44±0.43	6.67±0.02	3.20±0.06	-0.54±0.005
Wet X Humpless crosses	1029.27±0.25	6.66±0.01	3.24±0.05	-0.54±0.003
Dry X Sanga	1028.52±0.17	6.72±0.01	3.10±0.03	-0.54±0.002
Wet X N'Dama	1027.76±0.64	6.69±0.03	2.90±0.14	-0.54±0.007
Dry X N'Dama	1027.79±0.68	6.75±0.04	3.31±0.10	-0.53±0.012
Dry X Humpless Crosses	1028.51±0.14	6.69±0.01	3.21±0.03	0.53±0.002
Dry X Humped Crosses	1027.84±0.17	6.70±0.01	3.17±0.03	-0.53±0.002
P Value	0.44	0.13	0.06	0.97

± SE = Standard Error

ductivity but showed no significant influence on milk freezing point (Table 9). Milk in the first month, had the highest density and it was significantly denser than milk produced by the lactating cows in the fourth to the sixth month. The density of milk produced in the sixth month was the lowest but it was statistically similar to the density of milk produced in the 4^{th} to 8^{th} months of lactation.

The highest milk conductivity value of 3.44 mS/cm was obtained for the milk produced in the first month of lactation (ie 3.44 mS/cm). This figure was significantly higher than the figures (ranging 2.93 to 3.25 mS/cm) obtained for the second to the eighth months.

DISCUSSION

Effect of breed on milk yield and nutrient composition

The interaction between breed and season neither influenced the milk yield nor the nutritional composition of the milk collected in the study area. Gudali cows recorded the highest milk yield (2210 g/day) among the breeds under study however, it was lower than the 5190 g/day, 4700 g/day and 4300 g/day but close to 2400 g/day recorded for Gudali cows fed with Leucaena silage, Gliricidia silage, grass silage and Enterolobium silage respectively (Olorunnisomo 2013). The average daily milk yield (447.8 g) recorded for WASH cows in this study was lower than 3700 g recorded for indigenous breeds (Maharana and Mishra, 2020). WASH cows in the rainy season recorded 502 g in his study and was lower than 3100 g reported by Aboagye (2002) and 1550 g (Coffie *et al.,* 2015) for average milk yield in the rainy season. The highest milk yield per day per cow (in this study) recorded on a farm was 1687.66 g and it was lower than the 2214.60 g recorded for the Gudali cows whilst the lowest was 1142.82 g which was higher than the 447.78 g for the WASH cows. This was because no farm block was seen to have only one breed of cows. They all had two or more breeds with crosses on the farms. The differences in milk yield performance of the present and previous cows may be partly blamed on differences in parity of cows, intensity of selection of cows for milk production and the level of nutrition. The method by which milk yield was calculated may also partly account for the differences. It was also observed that Gudali cows recorded the highest total solid (13.91 %) content of milk among the breeds and was higher than 12.46 -12.54 % reported by Abbaya *et al.* (2021). As the Gudali cows recorded the highest milk yield among the breeds, it also recorded the

Table 9: Mean (± SE) Density, pH, Conductivity and freezing Point of milk Produced by cows within 8 months of lactation

Stage of Lactation (Month)	Milk Density (g/cm^3)	pH	Milk Conductivity (mS/cm)	Milk Freezing Point (^oC)
1	1029.10±0.23a	6.64±0.01b	3.44±0.04a	-0.54±0.002
2	1028.73±0.15ab	6.69±0.01ab	3.25±0.03b	-0.54±0.003
3	1028.55±0.16ab	6.71±0.01a	3.21±0.03b	-0.54±0.002
4	1028.21±0.17b	6.72±0.01a	3.22±0.03b	-0.54±0.002
5	1028.20±0.17b	6.73±0.03a	3.15±0.04b	-0.54±0.002
6	1027.89±0.23b	6.74±0.01a	3.16±0.04b	-0.54±0.003
7	1028.18±0.41b	6.73±0.02a	3.14±0.08b	-0.54±0.003
8	1028.28±0.85b	6.76±0.03a	2.93±0.10b	-0.56a±0.008
P value	0.002	< 0.001	< 0.001	0.28

Means that do not share a common letter in the same column are significantly different. (P<0.05). Those without letters in the same column are similar. ± SE = Standard Error highest (120 g) milk fat yield among them however, was lower than 3650 g reported by Abbaya *et al.* (2020) for Gudali cows.

Effect of stage of lactation on milk yield and nutrient composition

The 12.92 – 14.27 % total solids recorded in this work met the European Union's standard of not less than 12.5 % as reported by FAO/WHO (2007). As the stage of lactation increases, the total solid increases either significantly or nominally.

The fat content of milk increased from the first month of lactation i.e. 4.48% until it reached the highest level of 5.76% in the eighth month with a decline in the sixth month of lactation. This could be due to the increasing demand of higher nutrition for the growing calves (Hand, 1998). The general increase in the fat content of the milk in early lactation is in line with the observation of Sala *et al*. (2010).

The observed lactose values of the milk in the study area fell within the acceptable values of 4.5 to 5.2 g per 100 g reported by Mourad *et al.* (2014). This is an indication of high energy content of the milk and the provision of high energy to the consumers. The calculated energy showed significant ($p<0.05$) differences and had a pattern which was similar to that of lactose in the milk. This may be due to the fact that lactose levels influenced energy content of milk greatly since the levels of milk fat were similar.

Effect of breed on the physicochemical properties of Milk produced on farms in Ejisu/Juaben Municipality

All the pH values recorded for milk produced by the various breeds used in this study fell within the acceptable range of 6.6 to 6.8 (O'Connor, 1995; FAO, 1999) except that of milk from WASH in the dry season which was above 6.8. A pH above 6.8 is an indication of mastitis (O'Connor, 1995) and may mean that some of the herdsmen may be adding milk from diseased animals to the bulk milk for sale.

The variations observed in milk freezing points recorded for milk from the various breeds of cows used for the study confirmed the report given by Kędzierska-Matysek *et al.* (2011) and Gencurova *et al.* (2008) that breed of cows influence milk freezing point.

Milk conductivity is the measure of total concentration of electrolytes in milk, and breed had a significant ($P < 0.05$) influence on it in the present study. This result supports a study by Stanek (2024) who reported that breed significantly influences milk conductivity. The 4.68 mS/cm reported by Mucchetti *et al.* (1994) was above what was recorded in this study. The WASH had the highest conductivity followed by the cross (both humped and humpless) with Sanga recording the lowest. The difference in the values observed in this study and that of the earlier work (4.68 mS/cm) may be due to variation in milking interval, breeds and forages consumed as reported by Biggadike *et al*. (2000), Isaksson *et al*. (1987) and Mucchetti *et al.* (1994).

Effect of stage of lactation on the physicochemical properties of milk produced on the farms in Ejisu/Juaben Municipality

The significant differences observed in milk conductivity are in line with Biggadike *et al.* (2000) who indicated that stage of lactation influences milk conductivity. The insignificant influence of stage of lactation on milk freezing point is contrary to the observation made by Sala *et al.* (2010) who reported that milk collected in early lactation records higher freezing point than milk taken during late lactation but agrees with those of Senevirathne *et al.* (2016) that possible changes that might take place in the course of lactation does not influence milk freezing point values.

The milk density which dropped significantly from 1029100 g/m^3 in the first month to 1027890 g/m^3 in the sixth month were lower than a milk density of 103000 g/m^3 for raw milk reported by Tadjine *et al.* (2019). The differences in the figures could be due to the differences in breed of cows used.

Though there were significant ($p<0.05$) differences among the pH values at the various stages, they all fell within the acceptable pH of 6.6 to 6.8 (O'Connor, 1995; FAO, 1999) and pH of 6.65 to 6.76 (Nian *et al.*, 2012) previously reported. Cows suffer from mastitis if pH of the milk they produce is above 6.8 and milk pH from 6.6 to 6.8 is an indication that the animals were free from mastitis (O'Connor, 1995; FAO, 1999). This means that the lactating cows were not suffering from mastitis and the milk did not deteriorate due to microbial activity. This implies that irrespective of the stage at which the milk was produced, the milk pH should be within the acceptable range.

The 3.44 mS/cm recorded for conductivity in milk shows the concentration of ions in the milk produced in the first month of lactation and 2.93 mS/cm in the 8 months of lactation. It can be observed that milk conductivity decreased from the second month to the eighth month. However, the range of value for milk conductivity of the milk produced within in the first 8 months of lactation (2.93 - 3.44 mS/cm) are lower than the normal range of values (4.0 - 5.5 mS cm^{-1}) reported by Henningsson *et al*., (2005). The decline in milk conductivity along the stage of lactation is possibly due to the variation in the stage and composition of the forage consumed during that phase of the study (Mucchetti *et al*., 1994; Biggadike *et al*., 2000; Isaksson *et al*., 1987).

CONCLUSION AND RECOMMENDATION

Gudali cows had the highest daily milk yield per cow of 2214.60g, which was similar to 1898.82 g milk recorded for humped crosses (Zebu crosses). Milk protein and total solids were significantly higher in the wet season and lactose content of milk showed significant difference from one community to the other. The study showed that Gudali cows and humped crosses (Zebu crosses) could be selected for milk production. It was recommended that herdsmen and cattle owners should be trained to keep records on lactating cows and be able select high performing cows for milk production.

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