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Morning, Evening and Entire Lactation Milk Yield and Composition of Jersey Cows under Hot and Humid Tropical Environment of Nigeria

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Abstract: ***This study was carried out to assess the morning, evening and entire lactation milk yield and composition of pure bred Jersey cows at a commercial feedlot dairy farm located in Edu Local Government Area, Kwara State, Nigeria. Twelve primiparous lactating cows were selected for the experiment. Cows with similar initial daily milk yield were placed in the same treatment group. There were six treatment groups, with two cows per treatment in a completely randomized design experiment. The morning and evening milk yield, proximate and mineral composition of the milk were determined. The average morning, evening and total daily milk yield ranged from 2.46 to 7.24 kg/cow/day; 0.61 to 4.93 kg/cow/day and 2.46 to 12.17 kg/cow/day respectively. The entire lactation total milk yield ranged between 1803.50 to 2696.90 kg, and the lactation length ranged between 301 and 305 days. The average daily lactation milk yield ranged from 5.93 to 8.86 kg/cow/day. The ranges of 9.37 to 12.67% milk protein, 4.83 to 6.07% milk fat and 3.97 to 5.37% lactose were observed. Magnesium (33.33 to 78.33 mg/100 g) and calcium (226.67 to 383.33 mg/100 g) constituted the lowest and highest concentrations of milk minerals. The proximate and mineral composition of the colostrum was consistently highest and decreased gradually in the early, mid and late lactation milk. The results of this work showed that the feeding of high protein grass silage and concentrate diet to Jersey cows produced high average daily milk yield up to 12.17 kg/cow/day with milk protein range of 9.37 to 12.67% and milk fat range of 4.83 to 6.07%.***

Keywords: Milk, Yield, Quality, Jersey Cows

1. Introduction

Dairy animals are able to utilize cheap roughages and agro-industrial by-products which are not directly utilized by man in order to produce high quality protein sources such as milk and meat. The Jersey breed is characterized by small body size, hardy and adaptable to adverse environments, low maintenance requirement, high milk fat content and good reproductive performance and has been selected for tropical research and development programs [1]. Although there is a concern about adaptation of pure exotic dairy cattle to tropical environment in terms of climate, feed and disease challenge, pure bred Jersey cattle have been raised by large scale private and state dairy farms in Nigeria. The lactation milk yield of 2229 kg for Jersey cattle was reported in Pakistan [2], while the value of 2155 kg in 336 days lactation length was recorded in Ethiopia [1]. Other researchers [3] stated that the chemical composition of milk from cows of various breeds were determined genetically. These authors further reported that the Jersey cow milk surpassed other dairy breeds in terms of the levels of milk protein, milk fat, calcium and vitamins, and also, some earlier researchers [4] stated that milk with higher contents of fat and protein command high premium. These researchers also explained that the prevailing need to bridge the gap between recommended animal protein intake and actual consumption in Nigeria informed the renewed effort channelled towards the importation of exotic breeds of dairy cattle into the country. Minerals in the form of inorganic elements in the diet are required for normal life processes. Animal tissues and feeds contain mineral elements in widely varying amounts and proportions. The major chemical components of milk include water, fats, proteins, carbohydrates, minerals, organic acids, enzymes and vitamins [5]. These authors studied various mineral elements in milk, such as sodium, potassium, calcium and magnesium, in Pakistan. The aim of this research work was to assess the average daily morning, evening, total, and overall average daily lactation milk yield of the Jersey cows. To draw the lactation curves of the average monthly milk yields of the experimental Jersey cows, and to determine the proximate and mineral composition of the milk at the end of the different stages of lactation.

2. Materials and Methods

Study site

The study was undertaken at a commercial feedlot dairy farm located in Edu Local Government Area, Kwara state, Nigeria.

Animals, management and feeding

Twelve primiparous Jersey cows were selected for the experiment. Cows with similar initial daily milk yield were placed in the same treatment group. There were six treatment groups, with two cows per treatment in a completely randomized design experiment. This study was carried out during the period of 1st February to 30th November, 2015. The cows were managed under intensive system, they were offered *Panicum maximum* grass silage and concentrate diet as shown in Table 1. Both the silage and concentrate diet were offered *ad libitum*. The calves were separated and never allowed to suckle their dam. Calves were bottle fed with colostrum or mature milk twice daily until about four months of age, and then gradually they were introduced to starter diet and grass hay.

Milking of cows
The lactating Jersey cows were machine milked twice daily, at 8.00 h and 16.00 h. Milk yield of each cow was recorded mechanically through sensors connected to a computer. Morning and evening milk yield records of each experimental cow was obtained throughout the ten months lactation period.

Chemical analysis of feeds
Chemical composition of the *Panicum maximum* grass silage and the concentrate diet were determined. Dry matter was determined by oven drying samples at 105°C for 24 hours to a constant weight, and ash by igniting the samples in a muffle furnace at 600°C for 8 hours. Nitrogen, crude fibre and ether extract were determined according to the methods of AOAC [6]. Crude protein was calculated (N x 6.25) and nitrogen free extract (NFE) was also calculated (100 – (% CP + % CF + % EE + % Ash + % moisture). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were measured [7]. Hemi cellulose (HC) was calculated (HC = NDF – ADF). Non fibrous carbohydrate was calculated (100 – (% NDF + %CP + %EE + % ash).

Proximate composition of milk samples
Milk samples were analysed for proximate composition by analysing for total solids, fat (Gerber method), nitrogen and ash [6]. Percent protein (N X 6.38), solids-not-fat (%SNF) was calculated by difference (%SNF = %TS - % Fat). Percent lactose was also determined by using the Fehlings solution method [8].

Mineral composition of milk samples
Milk samples were analysed for the mineral components, calcium, phosphorus, magnesium, potassium and sodium [6].

Digestion
Amounts of 0.5g of the milk samples were weighed into a set of digestion tubes and 10mls each of perchloric and nitric concentrated inorganic acids were dispensed into the sample tubes. The samples were digested on the digestion block at 120°C for 2 hours, until the organic substances were completely decomposed. At the end of the digestion, the samples were allowed to cool to room temperature. Digested samples were made up to the 50 mls volume with deionized water and then transferred into centrifuge tubes and shaken for 10 minutes. The solutions were transferred to the centrifuge machine and centrifuged at the rate of 4500 rpm for 5 minutes. Finally, the supernatants were placed in duplicates in a set of pyrex glass vials and analysed for Ca, P, Mg, K and Na levels. The Ca and Mg were burnt off in an atomic absorption spectrophotometer (AAS) and the intensity of their flame was measured at the appropriate wavelength, current and pressure. Potassium and sodium was read off in the flame photometer. Phosphorus was measured calorimetrically using the vanado-molybdate reagent [6]. The results were then expressed in mg/100 g.

Statistical analysis
Data generated from the experiment were subjected to one way analysis of variance (ANOVA) procedure [9], using the completely randomized design. Significant means were separated using the Duncan's multiple range test of the same software. Mean differences were considered significant at $P<0.05$.

3. Results

Ingredients and chemical composition of *Panicum maximum* silage and concentrate diet
Table 1 shows the ingredients and chemical composition of *Panicum maximum* silage and concentrate diet. The crude protein contents of 15.30% for the *P. maximum* silage and 20.90% for the concentrate diet were both high. The crude fibre, neutral and acid detergent fibre and hemi-cellulose contents were adequate. The ether extract and ash contents of the silage (1.25% ether extract, 3.80% ash) and of the concentrate diet (4.10% ether extract, 4.53% ash) were low. The non-fibrous carbohydrate contents of 16.60% for the *P. maximum* silage and 24.25% for the concentrate diet were moderate.

Table 1: Ingredients and chemical composition of *Panicum maximum* silage and concentrate diet

Parameters	*Panicum maximum* silage	Concentrate diet
Ingredients (%)		
Cassava root meal	-	55.00
Palm kernel cake	-	21.00
Cotton seed cake	-	5.00
Soya bean cake	-	10.00
Maize	-	5.00
Bone meal	-	2.50
Salt	-	1.50
Total	-	100.00
Analysed contents (%)		
Dry matter	91.30	90.30
Crude protein	15.30	20.90
Crude fibre	19.40	12.65
Ether extract	1.25	4.10
Ash	3.80	4.53
Nitrogen free extract	51.55	48.12
Neutral detergent fibre	63.05	46.22
Acid detergent fibre	40.34	35.39
Hemi-cellulose	22.71	10.83
Non fibrous carbohydrates	16.60	24.25

Average daily morning, evening and lactation milk yield (kg/cow/day) of Jersey cows
The average morning, evening and total milk yield of Jersey cows are presented in Table 2, and the values were all significant ($P<0.05$). There was consistent decline in the average morning, evening and total milk yield of Jersey cows from the first to the tenth month, though there was a slight increase between the 4th and 5th month. During the 9th and 10th months of lactation, there was no evening milk yield by the cows. Shown in Table 3 are the average total milk yield, average lactation lengths and average daily lactation milk yield of the Jersey cows. The values of the total milk yield during one lactation (see Table 3) were not significantly different ($P>0.05$). However, the average daily lactation milk yield were significantly different ($P<0.05$).

Table 2: Average daily morning, evening and total milk yield (kg/cow/day) of Jersey cows

Month	Morning milk yield	Evening milk yield	Total milk yield
1	7.24^{a}	4.93^{a}	12.17^{a}
2	5.86^{ab}	4.66^{a}	10.52^{ab}
3	5.27^{b}	4.16^{ab}	9.43^{b}
4	4.64^{bcde}	3.54^{b}	8.18^{bc}
5	5.32^{bc}	4.03^{ab}	9.35^{b}
6	5.06^{bcd}	3.52^{b}	8.58^{b}
7	3.59^{def}	2.48^{c}	6.06^{cd}
8	4.11^{cde}	0.61^{d}	4.72^{de}
9	3.27^{ef}	-	3.27^{ef}
10	2.46^{f}	-	2.46^{f}
SEM	0.42	0.46	0.96
^{a,b,c,d,e,f} Means in the same column with different superscripts are significantly different (P<0.05);			
- no evening milk yield			

Table 3: Total milk yield, lactation lengths and average daily lactation milk yield of Jersey cows

Treatment	Total milk yield during one lactation (kg)	Lactation lengths (days)	Average daily lactation milk yield (kg/cow/day)
T1	2696.9	305	8.84^{a}
T2	2676.6	302	8.86^{a}
T3	1803.5	304	5.93^{c}
T4	2221.8	301	7.38^{b}
T5	1860.1	304	6.12^{c}
T6	1894.6	302	6.27^{c}
SEM	13.26	-	0.3
^{a,b,c} Means in the same column with different superscripts are significantly different (P<0.05); Means in the same column with no superscript are not significant (P>0.05)			

Lactation curves of monthly total milk yields of Jersey cows

Lactation curves of monthly total milk yields of Jersey cows are shown in Figure 1.

There were gradual decreases in milk yield from the 1st till the 4th month, and thereafter there was a rise in the 5th month until the 7th month. Finally there was steady decline in the various milk yield. The milk yield was lowest in the 10th month.

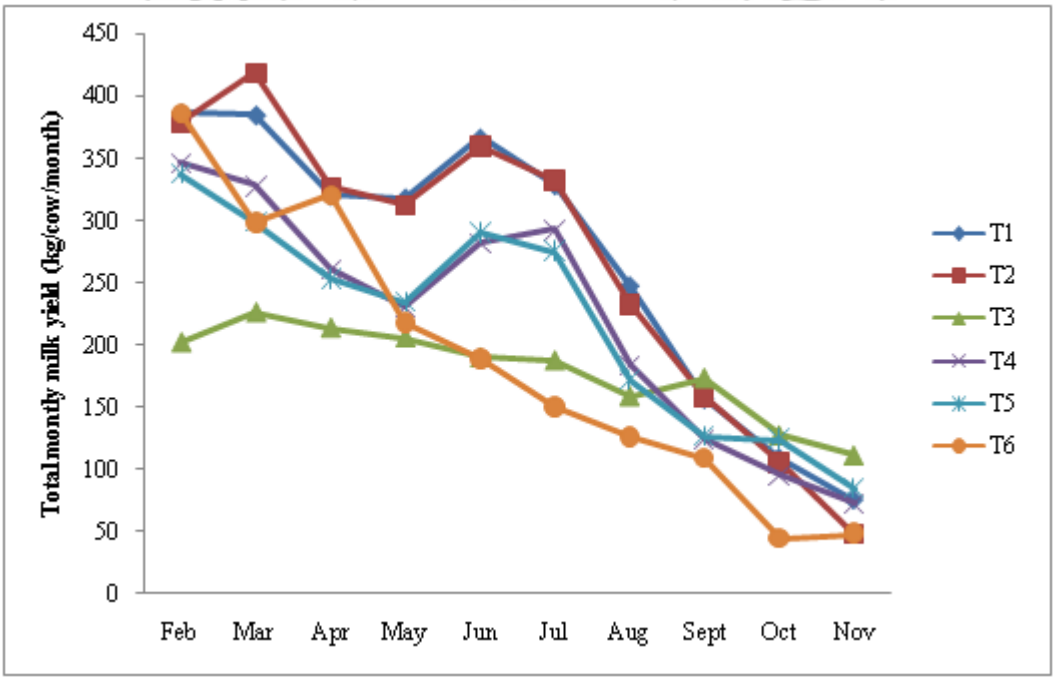

Figure 1: Lactation curves of monthly total milk yields of Jersey cows

Proximate and mineral composition of milk of Jersey cows during the different stages of lactation

Presented in Tables 4 and 5 are the proximate and mineral composition of milk of the Jersey cows during the four different stages of the lactation. The values were all significant (P<0.05) and most of these values were highest in colostrum and lowest in the late lactation milk.

Table 4: Proximate composition of milk of Jersey cows during different stages of lactation

Parameters (%)	Colostrum	Early lactation milk	Mid lactation milk	Late lactation milk	SEM
Total solids	21.23[a]	21.57[a]	20.73[b]	19.90[c]	0.20
Ash	1.37[a]	1.23[b]	1.17[bc]	1.07[c]	0.04
Lactose	3.97[d]	4.60[c]	5.07[b]	5.37[a]	0.16
Protein	12.67[a]	10.97[b]	10.13[c]	9.37[c]	0.37
Fat	6.07[a]	5.37[b]	5.23[b]	4.83[c]	0.14
Solids-not fat	15.16[c]	16.20[a]	15.50[b]	12.07[d]	0.20
Nitrogen free extract	5.23[b]	6.00[a]	6.20[a]	6.30[a]	0.14
[a,b,c,d] Means in the same row with different superscripts are significantly different (P<0.05)					

Table 5: Minerals composition of milk of Jersey cows during different stages of lactation

Minerals (mg/100g)	Colostrum	Early lactation milk	Mid lactation milk	Late lactation milk	SEM
Calcium (Ca)	383.33[a]	288.33[b]	228.33[c]	226.67[c]	19.33
Phosphorus (P)	281.67[a]	171.67[b]	128.33[c]	90.00[d]	21.84
Ca: P ratio	1.36:1	1.69:1	1.78:1	1.52:1	
Magnesium (Mg)	78.33[a]	43.33[b]	36.67[bc]	33.33[c]	5.52
Potassium (K)	176.67[a]	141.67[b]	116.67[c]	91.67[d]	9.85
Sodium (Na)	131.67[d]	181.67[c]	228.33[b]	263.33[a]	15.06
[a,b,c,d] Means in the same row with different superscripts are significantly different (P<0.05)					

4. Discussion

Ingredients and chemical composition of *Panicum maximum* silage and concentrate diet

The crude protein and crude fibre contents of both the *Panicum maximum* silage and concentrate diet were higher than the recommended levels of 12% crude protein and 25 to 28% fibre requirements for lactating cows [10]. Also, the values are adequate to meet the 8% crude protein needed to provide the minimum ammonia level required for normal functioning of the rumen micro-organisms for optimum rumen activity [11]. Non fibrous carbohydrate content of the diet of the ruminant serves as a source of energy. The optimal dietary level of non fibrous carbohydrate in dairy diet was suggested to be between 30 and 40% DM [12]. The non fibrous carbohydrate values (16.60 to 24.25%) obtained in this study is moderate to serve a good diet for the lactating Jersey cows.

Average daily morning, evening and lactation milk yield (kg/cow/day) of Jersey cows

The average daily morning, evening and total milk yield ranged from 2.46 to 7.24 kg/cow/day; 0.61 to 4.93 kg/cow/day and 2.46 to 12.17 kg/cow/day respectively. The morning milk yield was between 1.47 and 4.03 times greater than that of the evening milk yield. In a similar research, it was observed that morning milking gave significantly higher (P<0.05) quantity of milk than evening milking in Jersey cows managed in a dairy farm situated in Edu Local Government, Kwara State, Nigeria [4]. The range of the entire lactation milk yield obtained in this study was 1,803.50 - 2,696.90 kg between 301 and 305 days lactation lengths. These values are comparable to that reported from previous studies [2], in Pakistan. These authors [2] reported 2229 kg for entire lactation milk yield in pure bred Jersey cows. Also in another previous report [1] in the Central Highlands of Ethiopia, the observation of 2155 kg milk yield and 336 days lactation length for the entire lactation period of the pure Jersey dairy cows, were made. Also, the average daily lactation milk yield in the current study ranged from 5.93 to 8.86 kg/cow/day, which is in agreement with the value of 6.41 kg/cow/day reported in a previous study for pure breed of Jersey cows [1]. The average lengths of lactation period of between 301 and 305 days observed in this study were close to the 305 days recommended for commercial dairy operations [13].

Lactation curves of monthly average daily milk yields of Jersey cows

The lactation curves observed in this study showed a similar trend to that reported for Bunaji cows in an earlier research [14], which also recorded decreasing milk yield as the months in lactation of the cows advanced.

Proximate and Mineral Composition of Milk of Jersey Cows during Different Stages of Lactation

All the values obtained for the proximate and mineral composition of the experimental Jersey cows varied and were significantly (P<0.05) different during the different stages of lactation. The highest percentages of total solids (21.23%), ash (1.37%), protein (12.67%) and fat (6.07%) were significantly highest (P<0.05) in the colostrum and lowest in the late lactation milk. Values obtained in the current study are higher than the values of total solids (14.61%), ash (0.57%), protein (3.31%) and fat (5.77%) observed in a previous research using Jersey cows [4]. The range of 226.67 to 383.33 mg/100 g of calcium in milk of the Jersey cows recorded in this research was much higher than the value of 163.97 mg/ 100 g of calcium reported in an earlier research work [3] for lactating Jersey cows.

Magnesium (33.33 – 78.33 mg/100 g) and calcium (226.67 - 383.33 mg/100 g) constitute the lowest and highest concentrations of the Jersey cow milk minerals levels respectively in this study. The calcium: phosphorus ratios ranged between 1.36: 1 and 1.78: 1 in the current study. Generally it was observed that the milk quality (proximate and mineral composition) was consistently highest in the colostrum and continued to decline in the early, mid and late lactation milk. The calcium to phosphorus ratio of milk that was recorded in this study (1.15:1 – 1.23:1), is moderate as compared to the normal calcium: phosphorus ratio of 1.4: 1 [15], but was below the calcium: phosphorus ratio of 4.4 : 1 for cow milk in another report [16]. The results of this work showed that the feeding of high protein grass silage and concentrate diet to Jersey cows produced high average daily milk yield up to 12.17 kg/cow/day with milk protein range of 9.37 to 12.67% and milk fat range of 4.83 to 6.07%.

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