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Milk yield (offtake) and composition of White Fulani cows under free range grazing without and with concentrate supplementation

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Abstract: *The influence of supplementation with concentrate on milk yield (offtake) and composition in grazing White Fulani cows was investigated. Fourteen multiparous lactating White Fulani cows were assigned into two treatments of seven cows per treatment in a completely randomized design. Milk yield declined slightly from early lactation (2.01 and 2.23 kg/cow/day) to mid lactation (1.98 and 2.34 kg/cow/day) and then to late lactation (1.12 and 1.47 kg/cow/day) in the experimental cows under free range grazing only without concentrate supplementation (treatment 1) versus those offered free grazing plus concentrate (treatment 2). Milk crude protein contents were 3.55 and 3.80%, milk fat values were 4.46 and 4.70% and milk ash contents were 1.39 and 1.54%, in treatments 1 and 2 respectively. Milk mineral composition values were as follows: calcium (130.00 and 144.44 mg/100g); phosphorus (90.00 and 93.89 mg/100g); iron gave the lowest values (2.29 and 2.65 mg/100g) while sodium concentrations were highest (353.89 and 372.78 mg/100g). All observed results were significantly (P<0.05) higher in treatment 2 than in treatment 1. There were positive correlations between milk yield versus crude protein, solids-not-fat, total solids (r = 0.525; 0.552; 0.561) respectively. In conclusion, improvement in milk yield and composition of grazing cows could be achieved through concentrate supplementation.*

Key words: *Concentrate, cows, milk offtake, nutrients*

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I Introduction

In Nigeria, the nomadic pastoralist group is comprised mainly of the Fulanis, and they move in response to the seasonal grazing and water needs of their cattle herds and small ruminant flock. Cattle such as White Fulani, Sokoto Gudali, West African short horn (Muturu), N'dama, Red Bororo and Keteku are kept as status symbol, also for beef production, hides and skin, milk production as well as for tractor power on the farms. However, the White Fulani cattle is the leading triple purpose (milk, meat and draught) breed in West Africa (Belewu, 2006). In the transhumance system of ruminant livestock management, the pastoralists do have permanent homestead and bases, however, their animals depend on natural forage grasses and legumes for subsistence. Tona *et al*. (2015a) explained that the agro-pastoral system of cattle production in Nigeria provides feeds for ruminants mainly from the rangeland. That this however presents difficulties particularly during the dry season when there is low nitrogen content of the fodder.

It is well known that most Fulani pastoralists keep cattle mainly for beef production and only depend on the sales of the extractable milk to augment the income of the female members of their family. Such milk could also serve as a source of milk offtake for home consumption (Tona *et al*., 2015b). The Fulani pastoralists need to be educated continuously on the fact that concentrate supplementation in lactating cows could increase the quantity and quality of milk harvested.

The knowledge of the relationship between milk production and milk composition traits is beneficial in the formulation of programmes for selection and improvement of milk quantity and quality of dairy cattle (Alphonsus and Essien, 2012). Alphonsus (2015) also stated that generally, the correlation between the traits of economic importance is essential to predict the change in one trait in response to selection for the other. Effort therefore was made in this study to compare the effect of milk yield and quality in White Fulani cows under free range grazing without and with concentrate supplementation and correlation characteristics were examined.

II Materials and Methods

2.1 Study location

The experiment was conducted at the Teaching and Research Farm, Kwara State University, Malete, Kwara State, Nigeria between August, 2014 and July, 2015.

2.2 Experimental animals, management and feeding

Fourteen multiparous lactating White Fulani cows weighing 265.00 ± 15.00 kg with similar milk production were selected from a herd for the study. The animals were assigned into two treatment groups of seven cows per treatment. They were identified by the use of neck chains with number tags. The calves were allowed to suck milk freely from their dams throughout the period of the experiment. All the experimental animals were allowed free grazing from 9.00 am till 3.00 pm. *Andropogon gayanus*, *Centrosema pubescens* and several other forages were growing on the grazed range land. The cows in one of the two treatment groups were allowed only free range grazing. However, the second treatment group was offered free range grazing and also given 1 kg/cow/day of the concentrate as supplementary feed before the hand milking process and there after. Water and salt licks were made available to the animals *ad libitum*.

2.3 Milking of cows

The experimental cows were hand-milked once daily between 8.00 and 9.00 a.m. The calves were allowed to suck milk from their dams briefly before the hand milking process so as to stimulate milk letdown. Daily milk yield per cow was recorded and milk samples were collected for laboratory analysis.

2.4 Gross composition of concentrate diet

Concentrate diet was compounded using dried cassava peels, palm kernel cake, wheat offals, bone meal, vitamin/mineral mix and salt (as shown in Table 2).

2.5 Chemical composition of the grass and legume forages and concentrate diet

Chemical composition of the *Andropogon gayanus* grass, *Centrosema pubescens* legume (found growing on the grazed range land) and the concentrate diet were determined. Dry matter was determined by oven drying samples at 105^{o}C for 24 hours to a constant weight, and ash by igniting the samples in a muffle furnace at 600^{o}C for 8 hours. Nitrogen, crude fibre and ether extract were determined according to the methods of AOAC (2005). Crude protein was calculated (N x 6.25) and NFE was also calculated (100 – (% CP + % CF + % EE + % Ash + % moisture). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were measured by the methods of van Soest *et al.* (1991). Hemi cellulose (HC) was calculated (HC = NDF – ADF). Non fibrous carbohydrate percentages were calculated (100 – (% NDF + %CP + %EE + % ash). Mineral contents of the concentrate (calcium, phosphorus, iron and sodium) were determined on aliquots of the solutions of the ash by established atomic absorption spectrophotometer and calorimetric means using the vanadomolybdate methods (AOAC, 1990).

2.6 Proximate and mineral composition of milk samples

The proximate composition of the milk samples was determined for total solids, fat (Gerber method), nitrogen and ash (AOAC, 2005). Percent crude protein (N X 6.38), solids-not-fat (%SNF) was calculated by difference (%SNF = %TS - % Fat). Minerals in the milk samples were analysed by the methods of AOAC (2005). Digestion of the milk samples were carried out as outlined (AOAC, 2005; Tona *et al*., 2015a)

2.7 Statistical analysis

Data collected were subjected to t test and means were compared by Duncan's multiple range test, and also correlation analysis was carried out using the SPSS (2012) statistical package. Means were considered significant at $P<0.05$.

III Results And Discussion

3.1 Chemical composition of the experimental diets

Presented in Table 1 is the chemical composition of the grass and legume forages found in the grazing range land, and in Table 2 is the chemical composition of concentrate diet. The chemical composition of the grass, legume and concentrate diets showed that these diets could meet the minimum recommended levels of 12% crude protein and 25 to 28% fibre requirements for lactating cows (NRC, 2001). However, without the supplementation with concentrate, the grass and legume alone might not adequately provide the minimum 12% crude protein required. Also the diets could fall short of the 8% crude protein needed for the minimum ammonia level for optimum functioning of the rumen (Norton, 1995). The range of 7.30 – 14.42% ash content of the experimental diets was within the 6.68 – 9.48% ash content of foliage plants recommended for ruminants feeding (Ogunbosoye *et al*., 2015). Abdollahzadeh *et al.* (2010) suggested that the optimum dietary level of non fibrous carbohydrates in dairy ruminants diets should be between 30 and 40% DM. In the current research, the non fibrous carbohydrates content of between 9.77 and 49.71% was adequate to provide required nutrients for the experimental animals. Non fibrous carbohydrates contents of the diet in ruminants serve as a source of energy (Tona *et al.*, 2015b).

Table 1 Chemical composition of grass and legume forages of the grazed range land

Parameters (%)	*Andropogon gayanus*	*Centrosema pubescens*
Dry matter	90.38	94.26
Crude protein	7.19	6.33
Ether extract	3.53	2.95
Crude fibre	29.02	33.33
Ash	14.42	9.79
Nitrogen free extract	36.22	41.86
Neutral detergent fibre	65.09	31.22
Acid detergent fibre	52.12	16.49
Hemi-cellulose	12.97	14.73
Non fibrous carbohydrates	9.77	49.71

Table 2 Composition of the concentrate diet

Gross composition (%)	
Dried cassava peels	50.00
Palm kernel cake	27.00
Wheat offal	20.00
Bone meal	1.00
Vitamin/mineral mix	1.00
Salt	1.00
Total	100.00
Chemical composition (%)	
Dry matter	90.50
Crude protein	37.80
Ether extract	6.20
Crude fibre	0.87
Ash	7.30
Nitrogen free extract	38.33
Neutral detergent fibre	24.85
Acid detergent fibre	13.59
Hemi-cellulose	11.26
Non fibrous carbohydrates	23.85
Mineral composition (mg/100g)	
Calcium	386.70
Phosphorus	276.70
Iron	8.70
Sodium	948.30

3.2 Average milk yield (offtake) (kg) of lactating White Fulani cows without and with concentrate supplementation

The average milk yield (offtake) of experimental cows and the corresponding lactation curves are shown in Table 3 and Fig. 1. The early, mid and late lactation milk yield (offtake) of the experimental cows were significantly ($P<0.05$) higher in the cows that were given concentrate diet along with the grasses and legumes obtained from grazing range land. The average milk yield ranged from 1.12 to 2.01 kg/cow/day in cows without concentrate supplementation and ranged from 1.47 to 2.23 kg/cow/day in cows with concentrate supplementation. The same results were reflected in the monthly lactation curve of milk yield (offtake) of the experimental cows as shown in Fig. 1. The range of 1.47 to 2.23 kg/cow/day observed in this research for the grazing lactating White Fulani cows (with concentrate supplementation) were lower than the range of 2.29 to 3.28 kg/cow/day reported by Tona *et al*. (2015a) for grazing White Fulani cows fed 0, 20 and 30% dietary levels of soya milk residue. The values observed in this study were however higher than the range of between 0.16 and 0.46 kg/cow/day reported in the study of Ndubueze *et al*. (2006) for grazing White Fulani cows fed poultry-waste-cassava peel concentrate diets. The value of average range of milk offtake of 1.12 to 2.01 kg/cow/day reported for grazing White Fulani cows (without concentrate supplementation) in the present study was much higher than the average milk offtake value of 0.60 kg/cow/day observed by Olafadehan *et al*. (2013) for grazing traditionally-managed White Fulani cattle under small holder dairy production systems (without concentrate supplementation).

Table 3 Average milk yield (offtake) (kg) of lactating White Fulani cows without and with concentrate supplementation

Milk yield (offtake)	Months of lactation	Without concentrate supplementation	With concentrate supplementation	SD
Early lactation	1st to 3rd	2.01[b]	2.23[a]	0.007
Mid lactation	4th to 7th	1.98[b]	2.34[a]	0.068
Late lactation	8th to 10th	1.12[b]	1.47[a]	0.455

[a,b] Means in the same row with different superscripts are significantly different (P<0.05)

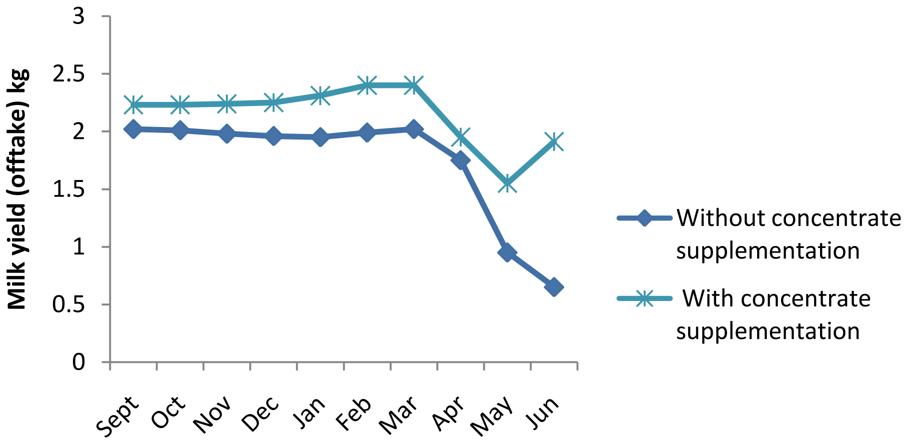

Figure 1 Monthly lactation curves of milk yield (offtake) of White Fulani cows without and with concentrate supplementation

3.3 Milk proximate and mineral composition of lactating White Fulani cows without and with concentrate supplementation

Shown in Table 4 is the proximate and mineral composition of lactating White Fulani cows without and with concentrate supplementation. The results showed that all the observed values were significantly higher (P<0.05) in the experimental cows with concentrate supplementation than those kept under free range grazing without concentrate supplementation. All the results observed for the milk proximate and mineral composition in the current study were significantly higher (P<0.05) in the experimental cows that were grazed and also offered concentrate than those that were grazed without being fed with concentrate. The values of 3.55% CP, 4.46% fat and 1.39% ash observed in the experimental cows grazed without concentrate supplementation were higher than the 1.25% milk CP and 3.7% milk fat reported by Akinlade *et al*. (2009) in sole *Pennisetum purpureum* grass fed Bunaji (White Fulani) cows. The values of 3.80% CP, 4.7% fat and 1.54% ash reported for concentrate supplemented experimental cows in the present study are close to the ranges of 3.46 to 3.58% milk CP, 3.78 to 5.07% milk fat observed in an earlier research (Ndubueze *et al*., 2006), and also comparable with the 3.38 to 3.65% CP and 3.75 to 4.70% fat observed in the report of Tona *et al*. (2015a) for grazing lactating cows fed with concentrate diets.

The values of 130.00 mg/100g calcium and 90.00 mg/100g phosphorus in the grazed experimental lactating cows (without concentrate supplementation) and 144.44 mg/100g calcium and 93.89 mg/100g phosphorus in the grazed lactating cows (with concentrate supplementation) were close to the ranges of 100.00 to 112.01 mg/100g calcium and 85.00 to 97.00 mg/100g phosphorus observed in the research of Tona *et al*. (2015a).

Table 4 Milk proximate and mineral composition of lactating White Fulani cows without and with concentrate supplementation

Parameters	Without concentrate supplementation	With concentrate supplementation	SD
Proximate composition (%)			
Total solids	15.40[b]	16.44[a]	0.82
Crude protein	3.55[b]	3.80[a]	0.33
Butter fat	4.46[b]	4.70[a]	0.36
Solids-not-fat	10.94[b]	11.74[a]	0.18
Ash	1.39[b]	1.54[a]	0.33
Nitrogen free extract	6.00[b]	6.40[a]	0.76
Mineral composition (mg/100g)			
Calcium	130.00[b]	144.44[a]	19.15
Phosphorus	90.00[b]	93.89[a]	12.44
Iron	2.29[b]	2.65[a]	0.28
Sodium	353.89[b]	372.78[a]	25.09

[a,b] Means in the same row with different superscripts are significantly different (P<0.05)

3.4 Correlation between milk yield (offtake) and milk proximate components without and with concentrate supplementation

Pearson correlation between milk yield (offtake) and milk proximate components without and with concentrate supplementation are presented in Tables 5 and 6. In the experimental lactating White Fulani cows which were grazed without being offered concentrate diet, the correlation between the milk yield (offtake) and milk proximate components were positive except that between milk yield (offtake) and fat (r = - 0.474). The negative correlation between milk yield and fat had also been reported by other researchers (Alphonsus and Essien, 2012; Alphonsus, 2015; Tona *et al*., 2015a). Alphionsus (2015) explained that this suggested that selection for improved milk yield could decrease the merit of the cows for milk fat content. There were significant (P<0.01) positive correlations between ash and SNF (r = 0.911), ash and TS (r = 0.907), SNF and TS (r = 1.000). Similarly, Alphonsus and Essien (2012) observed positive correlation among some milk proximate components. These were as follows: ash versus SNF (r = 0.352), ash versus TS (r = 0.434), SNF versus TS (r = 0.953). These authors (Alphonsus and Essien, 2012) explained that the positive correlation among fat, ash, SNF and TS indicated that these traits depend on each other and thus selection in one of these traits could lead to an increase in the other.

In the experimental cows which were grazed and also offered the concentrate diet, it was observed that there were negative correlations between milk yield (offtake) versus crude protein (r = - 0.597), milk yield (offtake) versus fat (r = - 0.397) and milk yield (offtake) versus ash (r = - 0.993). Similarly, Alphonsus and Essien (2012) observed negative phenotypic correlation between total milk yield (TMY) versus CP (r = - 0.018), TMY versus fat (r = - 0.235), TMY versus ash (r = - 0.577). Alphonsus (2015) also found negative pearson correlations between total milk yield (TMY) versus milk protein content (MPC) (r = - 0.214) and TMY versus milk fat content (MFC) (r = - 0.680). Tona *et al.* (2015a) also observed that there were significant (P<0.01) but negative correlations between TMY versus MFC (r = - 0.998). Again, in the current research work, there were some positive correlations among some milk proximate composition characteristics in the experimental cows with concentrate supplementation. These were as follows: ash versus CP (r = 0.500), ash versus fat (r = 0.500), SNF versus fat (r = 0.803), TS versus fat (r = 0.585).

Table 5 Pearson correlation between milk yield (offtake) and milk proximate components without concentrate supplementation

	MY	CP	Fat	Ash	SNF	TS
Milk yield (MY)	-					
Crude protein (CP)	0.525*	-				
Fat	-0.474	0.500*	-			
Ash	0.160	-0.756*	-0.945**	-		
Solids-not-fat (SNF)	0.552*	-0.419	-0.996**	0.911**	-	
Total solids (TS)	0.561*	-0.410	-0.995**	0.907**	1.000**	-

*P< 0.05; **P<0.01

Table 6 Pearson correlation between milk yield (offtake) and milk proximate components with concentrate supplementation

	MY	CP	Fat	Ash	SNF	TS
Milk yield (MY)	-					
Crude protein (CP)	-0.597*	-				
Fat	-0.396	-0.500*	-			
Ash	-0.993**	0.500	0.500*	-		
Solids-not-fat (SNF)	0.229	-0.918**	0.803**	-0.115	-	
Total solids (TS)	0.513*	-0.995**	0.585*	-0.410	0.953**	-

*P< 0.05; **P<0.01

IV Conclusion

This study has demonstrated that improvement in milk yield and composition of grazing cows could be achieved through concentrate supplementation.

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