Tropical and Subtropical Agroecosystems

MILK YIELD AND COMPOSITION OF PREPARTUM BUNAJI COWS SUPPLEMENTED WITH AGROINDUSTRIAL BY-PRODUCTS IN SMALLHOLDER DAIRY PRODUCTION SYSTEMS

[RENDIMIENTO Y COMPOSICIÓN DE LA LECHE DE VACAS BUNAJI SUPLEMENTADAS CON SUBPRODUCTOS AGROINDUSTRIALES EN FINCAS DE SISTEMAS DE PRODUCCION LECHERA]

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SUMMARY

Twenty cows gestating Bunaji cows, balanced for their weight and parity, were submitted to four treatments: T1, range grazing, (RG); T2, RG + 100% corn bran (CB); T3, RG + 60% CB + 40% palm kernel cake (PKC), and T4, RG + 60% CB + 40% dried brewer's grains (DBG) in an on-farm experiment in a complete randomized design. Mean milk offtake (kg/day) at 3 months, 6 months and weaning were lower (P < 0.05) in cows on T1 than T2, T3 and T4 (0.60 vs. 0.77, 0.93 and 0.95), (0.41 vs. 0.52, 0.60 and 0.62) and (0.26 vs. 0.33, 0.41 and 0.43), respectively. Mean milk yields at 3 months, 6 months and weaning, 4% FCM and total milk yield throughout lactation were superior (P < 0.05) in T3, T2 and T4 compared to T1 (2.91, 3.16 and 3.29 vs. 2.53 kg/day), (2.53, 2.68 and 2.68 vs. 2.29 kg/day) and (2.16, 2.28 and 2.31 vs. 1.79 kg/day), (3.22, 3.48 and 3.59 vs. 2.57 kg/day) and (532.66, 577.29 and 591.31 vs. 435.94 kg), respectively. Among the supplemented cows, the above mentioned milk parameters were lower (P < 0.05) in T2 and higher in T4. Time to peak milk production and milk constituents were similar (P > 0.05) among the treatments. Total milk offtake and peak milk production significantly varied among the treatments; the rank order was: T1 < T2 < T3 < T4 (all P < 0.05). Milk yield was largely an inverse linear function of month of lactation (r = -0.98, P < 0.001). Results indicate that strategic supplementary feeding of pregnant cows in an on-farm situation will improve the lactation performance of cows, and quality of concentrates used as supplement should be prioritized.

Keywords: Lactation performance; milk components; strategic supplementation; agroindustrial by-products; cows

RESUMEN

Veinte vacas Bunaji, gestantes y agrupadas acorde a peso y número de parto fueron evaluadas en cuatro tratamientos: T1, pastoreo de agostadero, (RG); T2, RG + 100% salvado de maíz (CB); T3, RG + 60% CB + 40% pasta de fruto de palma (PKC), y T4, RG + 60% CB + 40% grano seco de destilería (DBG) en un experimento realizado en finca. La toma de leche (kg/día) a 3 y 6 meses y al destete fue menor (P < 0.05) en vacas de T1 que en aquellas en T2, T3 y T4 (0.60 vs. 0.77, 0.93 y 0.95), (0.41 vs. 0.52, 0.60 y 0.62) y (0.26 vs. 0.33, 0.41 y 0.43), respectivamente. La producción de leche a los 3 y 6 meses y al destete, producción ajustada a 4% de grasa, producción total en lactancia fue superior (P < 0.05) en T3, T2 y T4 comparado con T1 (2.91, 3.16 y 3.29 vs. 2.53 kg/d), (2.53, 2.68 y 2.68 vs. 2.29 kg/d) y (2.16, 2.28 y 2.31 vs. 1.79 kg/d), (3.22, 3.48 y 3.59 vs. 2.57 kg/d) y (532.66, 577.29 y 591.31 vs. 435.94 kg), respectivamente. Entre las vacas suplementadas los parámetros fueron inferiores (P < 0.05) en T2 y mayores en T4. El tiempo al pico de lactancia y la composición de la leche fue similar entre los tratamientos (P > 0.05). La toma total de leche y la producción al pico de lactancia varió significativamente entre grupos T1 < T2 < T3 < T4 (todos P < 0.05). La producción de leche es presentada por una función lineal inversa al mes de lactancia (r = -0.98, P < 0.001). Los resultados indican que la suplementación estratégica de vacas gestantes en condiciones de finca mejorará el comportamiento durante la lactancia, y que la calidad de los alimentos utilizados como suplementos debe ser priorizada.

Palabras clave: Producción lechera; composición de la leche; suplementación estratégica; subproductos agroindustriales; vacas.

INTRODUCTION

In developing countries, smallholder dairy production attracts minimum investment in housing, feed and health-care. Among the numerous constraints to production, inadequate feed supplies remain a major constraint to sustainable cattle production in general, and milk production in particular, in smallholder dairy production systems (Olafadehan and Adewumi, 2008). In the production system under study, the smallholder dairy farmers rarely supplemented their stock, but graze their ruminant livestock predominantly and extensively on the unimproved native pastures (the major source of feed) and crop residues (often available after harvesting in the early dry season). Consequently, the problem of poor nutrition becomes exacerbated in the dry season when the animals are subjected to nutritional stress because the feed resources are senesced and in short supply leading to decreased animal productivity (Olafadehan and Adewumi, 2009). During the dry season, the crude protein content of most tropical grasses, which is lower than 7% dry matter (NRC, 1988), cannot meet the requirement for maintenance let alone for pregnancy and lactation. The multiple interaction of scarcity of good quality forage coupled with low nutritive content, intake, digestibility and poor utilization sum up to undernourish and depress productivity of animals to an appreciable extent and also limit the expression of milking potential of indigenous cattle. As a result of this, milk production in a smallholder dairy system is very low and below the genetic potential of the indigenous dairy cattle. The problem of forage availability and quality, which becomes critical during the dry season, therefore necessitates the need for sustainable and strategic supplementation. To make smallholder dairying profitable and sustainable, improved feeding through supplementation using relatively cheap and readily available agroindustrial by-products is a viable insurance towards feed availability and quality fluctuation. It was hypothesized that supplementary feeding of pregnant grazing cows during the critical dry season would improve the lactational performance of the animals.

This study aimed at assessing the effect of dry season strategic supplementation of prepartum Bunaji cows on the milk yield and composition in the ensuing lactation.

MATERIALS AND METHODS

Experimental site

The study was conducted on-farm among the agropastoralists who settled in the derived savanna of Oyo State. The study area lies roughly between longitude 3° 4′ West, 6° 4′ East of Greenwich and latitude 6^0 10′ and 9^0 10′ North of the equator. It is bounded in the north by the southern guinea savanna zone and in the south by the interface between the lowland rain forest and southern parts of the derived savanna. Annual rainfall is between 1,500 and 2,000mm and follows a bimodal distribution. The temperature ranges from 22 - 33^0C while the wet season lasts for 8.0 - 8.5 months starting from mid- to mid-November.

Husbandry and experimental design

The system under study is a traditional one in which cattle are herded to the fields in the morning after milking to graze natural forages and crop residues. They are returned in the evening and corralled during the night in the open field, near the homestead. Unweaned calves are tied by ropes to separate them from their dams. Cows are partially milked once a day in the morning, the remainder of the milk being suckled by the calves.

Twenty gestating dual purpose dairy Bunaji cows under the same herd management system in their 2nd and 4th lactation, with an average weight of 294.50 ± 3.75 kg, were used for the experiment. The cows were selected when they were in the last trimester of their pregnancy, which was determined by interviewing the herd owners. They were balanced for their weight and parity (lactation number) and separated into 4 groups of 5 cows each and submitted to a completely randomized design. The groups were randomly assigned to 4 treatments: T1, range grazing, (RG); T2, RG + 100% corn bran (CB); T3, RG + 60% CB + 40% palm kernel cake (PKC), and T4, RG + 60% CB + 40% dried brewer's grains (DBG) which were given to the animals for 98 days prior to calving.

Feeding strategy

The period from February to the end of April in the study area represents the nutritional stress period (critical dry season) when crop residues from the previous planting season, which are used as supplements to the basal feed (natural pastures), are exhaustively grazed while the quantity and quality of the standing forages are extremely poor. Although some grasses may become available in late April to mid-May, the dry matter content and hence intake is extremely low to confer much nutritional benefits. For these reasons, the experimental animals were strategically supplemented. Supplements were offered individually, early in the morning before grazing throughout the last trimester of pregnancy spanning February to May 2003, at 20% of the daily dry matter intake estimated at 3% body weight. After feeding, animals were grazed together on the same natural range consisting predominantly of gamba grass (*Andropogon gayanus*) and sparsely available elephant grass (*Pennisetum purpureum*), while available browse plants, *Alfzelia africana*, *Daniellia oliveri* and *Tephrosia spp* (*T. candida* and *T. bracteolata*) were occasionally lopped to feed the animals due to the inadequacy of native pastures. Common salt was offered to individual animals throughout the prepartum supplementation period. Supplement or feed intake was estimated as the difference between what was offered and rejected after each day feeding. However, feed refusal was very small and virtually negligible as all the cows finished their feed before going out for grazing.

Milking procedure

Milking of the cows began one week after calving to allow calves access to colostrum, but milk production records began two weeks after calving and continued throughout lactation which was taken as time the dams dried off or calves were naturally weaned as commonly practiced under traditional systems of management. However, milk yield record was initially taken on weekly basis for the first 12 weeks to determine the time the cows attained the peak of milk production. The daily milk offtake (ie extractable milk for human consumption) values measured at two-week intervals, using a volumetric cylinder, were averaged and multiplied by 30 to obtain a monthly offtake for each dam. Cows were hand-milked once daily in the morning between 0.700 to 0.800h local time while calves were used to initiate milk let-down. Partial milking was done in order to reserve milk for sucking calves, which were prevented from sucking the dams while on range by a means of Fulani apparatus called "Toide" placed around their necks. Milk offtake was determined at 3 months, 6 months of lactation and weaning of the calves. Estimated milk yield (MY) at 3 months, 6 months and weaning was calculated from the sum of the milk offtake (MO) and calf's growth (CG) x 9 (Agyemang et al., 1993). Calf's growth x 9 gave the estimate of the milk consumed by the calves.

Milk Yield = Milk Offtake + (Calf's Growth x 9)

Milk samples for constituent analysis were collected once every two months into bottles containing a pinch of potassium dichromate (K_2CrO_4) powder to maintain homogeneity and prevent clotting. The samples were kept chilled and later analyzed for milk components.

Chemical analysis

The proximate constituents of the experimental diets and milk were determined according to AOAC (1990) methods. Gross energy contents of feeds were determined using Gallen-Kamp ballistic bomb calorimeter (Modal CB- 370). The neutral detergent fiber and acid detergent fibre components were determined by methods of Van Soest *et al*. (1991). The NDF was analyzed using a heat stable α-amylase and without inclusion of sodium sulfite. Both ADF and NDF were expressed inclusive of ash.

Statistical analysis

Data were analysed using the procedure of statistical analysis software (SAS, 1999) and treatment means were compared using Duncan's procedure of the same software. The statistical model focused primarily on supplementation effect as the main treatment. The following model was thus used: $Y_{ij} = \mu + PS_J + e_{ij};$ where Y_{ij} is the dependent, continuous variable; μ is the overall mean; PSj is the fixed effect of the jth prepartum supplementation (j = 1, 2, 3, 4) and e_{ij} is the residual error. Relationship between milk yield and month of lactation was determined using simple regressions.

RESULTS

The proximate compositions of the basal range forages and supplemental diets are presented in Tables 1 and 2, respectively. The crude protein content of the supplemental diets was higher than the 11% recommended for dry pregnant cows (NRC, 1988). Mean milk offtake (extractable milk) at 3 months, 6 months and weaning showed the same trend and were lower ($P < 0.05$) in the non-supplemented cows on T1 than in the supplemented ones on T2, T3 and T4 (Table 3). Both total milk offtake and peak milk production varied among the treatments; the rank order was: T1 < T2 < T3 < T4 (all $P < 0.05$). . Total milk yield, 4% fat-corrected milk (FCM) and mean milk yields at 6 months and weaning were lower ($P < 0.05$) in the control than the treatment groups. Among the treatment groups, cows on T3 and T4 had higher ($P < 0.05$) total milk yield, 4% FCM and milk yields at 6 months and weaning than those on T2 (Table 3). Time to peak milk production was not influenced ($P > 0.05$) by the prepartum supplementary feeding of the dams (Table 3). Lactation curves (Figure 1) showed that there was a gradual increase in milk production up to about 2 months after which, there was a steady decline until lactation ceased at about 10 months.

Regression of the milk yield (Y) on months of lactation (X) showed that milk yield was largely an inverse linear function of month of lactation ($r = -0.98$, $P < 0.001$). The best-fit regression equation ($r^2 = 0.96$) for predicting milk yield of cows from the month of lactation is $Y = 3.383 - 0.138X$.

Milk components, total solids, fat, solids-not-fat (SNF), crude protein, lactose, ash and gross energy, were similar ($P > 0.05$) among all the treatments (Table 4). Except for fat and gross energy, values for all other constituents were highest for supplemented cows on T4 and least with the T1.

Table 1. Composition (%) of the range forages consumed by the experimental animals

	DM	OM	CP	Ash	NDF	ADF
Grasses						
A. gayanus	21.7	93.5	9.0	6.5	65.4	39.0
P. purpureum	37.7	89.2	11.4	10.8	64.4	41.5
Browse plants						
A. africana	39.5	93.1	22.0	6.9	56.1	33.6
D. oliveri	26.5	93.0	16.9	6.7	59.7	41.1
T. candida	25.8	88.0	19.3	12.0	49.5	59.1
T. bracteolata	29.7	97.0	14.3	3.0	36.5	56.0

DM = dry matter, OM = organic matter, CP = crude protein, NDF = neutral detergent fiber, acid detergent fiber

DISCUSSION

The higher daily milk offtake for and milk yields at various stages of lactation, 4% FCM and total milk offtake and yields in supplemented cows compared to that of their non-supplemented counterparts is probably a response to the extra dry matter intake, energy and nutrients consumed by the supplemented cows in addition to that supplied by the basal native pastures and the occasionally lopped browse plants. These findings suggest that supplementary feeding of grazing stock with agroindustrial by-products improves the supplies of fermentable energy and digestible protein which are needed for optimizing the efficiency of rumen functions for efficient utilization of low quality forages available during the dry season (Olafadehan and Adewumi, 2009). The increase in milk yield reported previously (Knowlton *et al*., 1996; Boddugari *et al*., 2001) was attributed to the improvement in nutrient availability and digestibility. Unfortunately, data from the current study do not allow inferences regarding rumen fermentation or total diet digestibility and effects on milk yield, but this reason remains plausible. These observations are corroborated by the previous findings (El-Tayeb and Takla, 1992; Bheekhee *et al*., 2002) who reported improved milk yield due to prepartum supplementation. Milk offtake at weaning, otherwise known as average milk offtake per lactation, was in the supplemented cows on T2, T3 and T4, 26.9, 57.7 and 65.4%, respectively, greater than in the non-supplemented cows on T1. Since the farmers depend on the sale of the extractable milk to augment their household income, it appears that prepartum supplementation would increase the benefits accruable to farmers. Olafadehan and Adewumi (2008) reported economic benefits of between 16.5 and 31.1% due to supplementary feeding of gestating grazing Bunaji cows in an on-farm experiment. The significant differences observed in milk offtake and milk yields among the supplemented cows is a reflection of the quality of concentrate rations used as supplements. These observations are consistent with previous reports (Agyemang *et al*., 1997; VanBaale *et al*., 2001; Schroeder, 2003; Kumaresan *et al*., 2008) who indicated the pronounced influence of feed quality on the milk offtake and yields. Corn bran is a rich source of ruminally degradable starch, whereas both PKC and DBG are moderate sources of protein. Consequently, the addition of these two protein sources to corn bran made the diets superior to corn bran diet only. Improved milk yield of cows supplemented with finely ground dry corn has been attributed to increased ruminally degradable starch which has been reported to improve lactational performance because of higher production of VFA and greater ruminal bacterial yields (Poore *et al*., 1993); finely ground corn had higher efficiency of conversion of feed to milk (Yu *et al*., 1998). Both milk yields and offtake were consistently highest for cows on T4 possibly because the diet had the highest amount of crude protein and energy (Table 1) which are essential for milk synthesis. This apart, the supplement contained DBG which has high amount of undegradable protein, making them a good source of rumen by-pass protein (Chiou *et al*., 1998). Cunningham *et al*. (1996) noted that the use of increased amount of rumen undegradable protein from dietary concentrates increased milk yield because of improved protein supply and improved intake of metabolisable energy from the concentrates.

Milk production increased steadily after calving, got to the peak between 5.6 and 6.4th weeks of lactation and declined progressively until the animals dried off. Lack of treatment effect on time to peak milk production in current study confirms previous findings (Kononoff *et al*., 2006) who observed similarities in time to peak production in Holstein cows fed wet corn gluten feed during the dry period and lactation compared to the control (cows not fed corn gluten meal). Time to peak milk production fell within the range of 3-9 weeks reported in the literature (Luck and Smith, 1975; Jenness, 1985; Bheekhee *et al*., 2002). The markedly higher peak milk production for the treatment groups than the control is consistent with previous observations (Kononoff *et al*., 2006).

The significant and negative correlation between milk yield and months of lactation are validated by the findings of Adu *et al*. (1974) who reported decreasing milk yield as lactation advances. They noted that milk production of prepartum supplemented West African Dwarf sheep was highest during the first three weeks and declined sharply during the next four weeks to a steadier decline in the remaining period of lactation.

Table 2. Composition (%) of the supplemental diets

	Treatments			
	T1	T2	T3	T4
Dry matter		91.9	91.4	91.3
Organic matter		96.5	95.4	95.5
Crude protein		13.0	15.4	15.7
Crude fibre		8.8	11.5	12.8
Ash		3.5	3.9	3.7
Ether extract		2.8	4.6	4.4
Total carbohydrates		80.7	76.1	76.2
NFC		29.9	19.3	19.6
Acid detergent fibre		28.2	33.5	33.2
Neutral detergent fibre		50.8	56.8	56.6
Gross energy MJ/kgDM		17.1	17.8	17.9

NFC = non-fibrous carbohydrates

Though milk components were fairly similar among the treatments (Table 3), supplemented cows showed persistently higher values for all the milk constituents, except for milk fat and gross energy, than the non-supplemented cows. The results have some nutritional implications especially for milk which quality is most often determined by its fat and SNF contents. The fact that the milk fat declined progressively from T1 to T4 and CP and SNF increased from T1 to T4 suggest that prepartum supplementary feeding of the cows slightly improved the nutritional quality of their milk. This is because the minimum standards for market milk are fixed for fat and SNF contents to ensure quality milk supply to the consumers and prevent adulteration of milk and that various grades of market milk are supplied to the consumer after standardization to the prescribed levels of fat and SNF content of milk. In the underfed animals the milk yield and SNF in milk are low and farmers suffer since low SNF milk is either not accepted or very low price is paid (Kumaresan *et al*., 2008). Svennersten-Sjaunja *et al*. (1997) analyzed various records of milk of cows on different farms in Sweden and found that the consumer's demand was milk with moderate or low fat content. It is difficult to speculate on the reasons for lack of treatment effect on the milk components. However, Chalupa *et al*. (1996) reported that the proportions of fat and protein in milk are determined primarily by genetics, though they can be changed by nutrition and methods that adjust digestive and metabolic processes. Corollary to this, Varga and Ishler (2008) reported that the concentrations of lactose and minerals, other solids constituents of milk, do not respond predictably to adjustments in diet. Lack of treatment effect on milk components agrees with the previous findings (Bheekhee *et al*., 2002).

Table 3. Lactation performance of prepartum supplemented cows

Item	Treatments				
	T1	T2	T3	T4	SEM
Milk offtake (kg/day)					
3 months	0.6^{c}	0.8^{b}	0.9^{a}	1.0^{a}	0.1
6 months	0.4^{c}	0.5^{b}	0.6^{a}	0.6^{a}	0.03
Weaning (milk offtake/lactation)	0.26^{c}	0.33^{b}	0.41^{a}	0.43^{a}	0.02
Total milk offtake (kg)	63.2^{d}	81.4^{c}	103.8^{b}	110.2^{a}	2.5
Milk yield (kg/day)					
3 months	2.5^{c}	2.9^{b}	3.2^{ab}	3.3^{a}	0.1
6 months	2.3^{c}	2.5^{b}	2.7^{a}	2.7^{a}	0.1
Weaning (milk yield/lactation)	1.8^{c}	2.2^{b}	2.3^{a}	2.3^{a}	0.1
Total milk yield (kg)	436^{c}	533^{b}	577^{a}	591^{a}	14
FCM (Kg/day)	2.9^{c}	3.2^{b}	3.5^{a}	3.6^{a}	0.1
Peak milk production (kg)	91.7^{d}	100.5^{c}	107.2^{b}	114.1^{a}	2.5
Time to peak production (weeks)	5.8	5.6	6.4	6.2	0.6

Means on the same row with different superscripts differ significantly ($P < 0.05$).
FCM = Fat-corrected milk

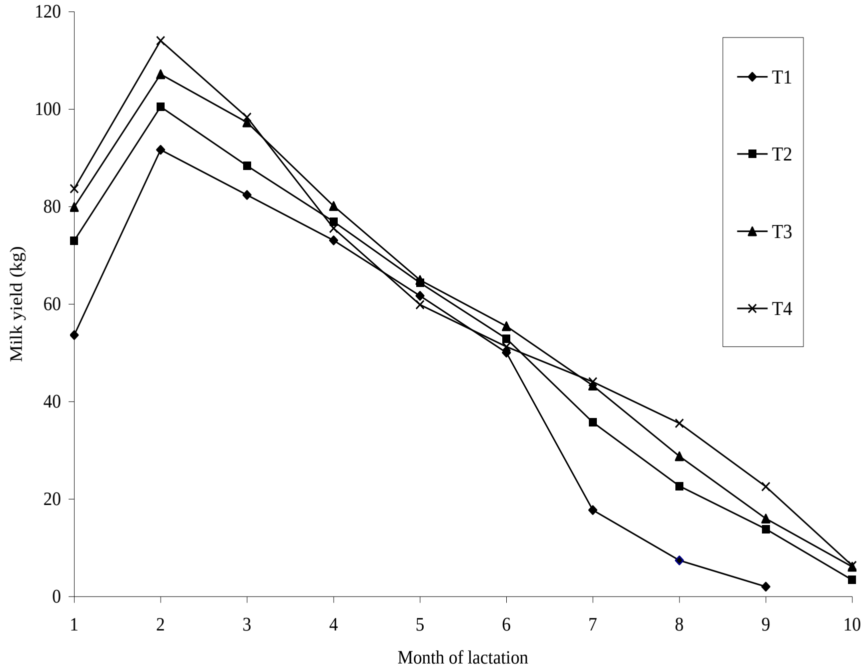

Fig. 1. Lactation curves of the experimental cows

Table 4. Chemical composition of milk of supplemented grazing Bunaji cows

	Treatments				
Constituents (%)	T1	T2	T3	T4	SEM
Total solids	13.5	13.7	13.6	13.7	0.1
Fat	4.9	4.7	4.7	4.6	0.1
Solids-not-fat	8.7	8.9	8.9	9.1	0.7
Crude protein	3.7	3.8	3.7	3.8	0.04
Lactose	4.4	4.6	4.6	4.7	0.2
Ash	0.5	0.6	0.5	0.6	0.03
Gross energy (cal/100g)	76.6	75.9	75.6	75.4	0.5

Mean on the same row without superscripts are not significantly different (P > 0.05).

CONCLUSION

Steaming up of grazing gestating cattle in smallholder dairy production systems can be strategized in such a way as to optimize both milk offtake and yield. This, however, requires a focused approach toward feed quality, feeding management, and nutrition. Therefore, agroindustrial by-products such as cheap and readily available corn bran, palm kernel cake and dried brewer’s grains can be used during the dry season in the tropical countries for improved milk production of prepartum cows in their last trimester of pregnancy thereby enhancing the economic profitability of the dairy business.

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REFERENCES

Adu, I. F., Olaloku, E. A. and Oyenuga, V. A. 1974. The effects of energy intakes during late pregnancy on lamb birth weights and lactation of Nigerian dwarf sheep. Nigerian Journal of Animal Production. 1: 151-161.

Agyemang, K., Clifford, D. J. and Little, D. A. 1993. An assessment of the biological and economic efficiency in conversion of milk to meat in N'Dama calves. Animal Production. 56: 165-170.

Agyemang, K., Dwinger, R. H., Little, D. A. and Rowlands, G. J. 1997. Village N'Dama Cattle Production in West Africa: Six Years of Research in The Gambia. Livestock Research Institute/International Trypanosomiasis Centre. pp. 136.

AOAC 1990. Official Methods of Analysis. 15th ed. Association of Official Analytical Chemists. Washington, DC.

Bheekhee, H., Hulman, B., Boodoo, A. A., Ramnauth, R. K., Lam Heung Yuen, R., Fakim, R. & Dobee, B. (2002). Development and field evaluation of animal feed supplementation packages for improving meat and milk production in ruminant livestock using locally available feed resources. In: Development and Field Evaluation of Animal Feed Supplementation Packages, Animal Production and Health Section, International Atomic Energy Agency Vienna. pp. 111 - 119.

Boddugari, K., Grant, R. J., Stock, R. and Lewis, M. 2001. Maximal replacement of forage and concentrate with a new wet corn milling product for lactating dairy cows. Journal of Dairy Science. 84: 873–884.

Chalupa, W., Galligan, D. T. and Ferguson, J. D. 1996. Animal nutrition and management in the 21st century: dairy cattle. Animal Feed Science Technology. 58: 1-18.

Chiou, P. W. S., Chen, K. J. and Yu, B. 1998. Wet brewer's grains or bean curd pomance as partial replacement of soybean meal for lactating cows. Animal Feed Science Technology. 74: 123-134.

Cunningham, K. D., Cecava, M. J., Johnson, T. R. and Ludden, P. A. 1996. Influence of source and amount of dietary protein on milk yield by cows in early lactation. Journal of Dairy Science. 79: 620-630.

El-Tayeb, A. E. and Takla, A. G. 1992. Effect of addition of concentrates to Sudan grass (*Sorghum sudanese*) in the pre-calving period on performance of Holstein-Friesian heifers in Sudan. In: The Complementarity of Feed Resources for Animal Production, Proceedings of Joint Feed Resources Networks Workshop, J. E. S. Stares, A. N. Said and J. A. Kategile (Eds.). ILCA, Botswana. pp. 259-263.

Jenness, R. 1985. Biochemical and Nutritional Aspects of Milk and Colostrums, B. L. Larson (Ed). IOWA State University Press, USA.

Kononoff, P. J., Ivan, S. K., Matzke, W., Grant, R. J., Stock, R. A. and Klopfenstein, T. J. 2006. Milk production of dairy cows fed wet corn gluten feed during the dry period and lactation. Journal of Dairy Science. 89: 2608-2617.

Knowlton, K. F., Allen, M. S. and Erickson, P. S. 1996. Lasalocid and particle size of corn grain for dairy cows in early lactation. 1. Effect on performance, serum metabolites, and nutrient digestibility. Journal of Dairy Science. 79: 557-564.

Kumaresan, G., Saravanakumar, K., Murugan, B., Rajendran, D., Devendran, P. and Annal Villi, R. 2008. Finely ground dry corn supplementation to improve solids not fat content of crossbred cattle milk during summer under tropical climate. Journal of Applied Science Research. 4(2): 202-206.

Luck, H. and Smith A. 1975. Relationship between constituent's concentration and pH value of mammary gland. South African Journal of Dairy Technology. 7: 27-30.

NRC 1988. Nutrients Requirements of Dairy Cattle. 6th Ed. National Research Council. Washington, DC.

Olafadehan, O. A. and Adewumi, M. K. 2008. Milk production and economic impact of strategic supplementation of prepartum Bunaji cows in the peri-urban areas of derived savanna of southwestern Nigeria. Livestock Research for Rural Development. 20(3). Electronic version: http://www.cipav.org.co/lrrd/lrrd/20/3/olaf20041.htm

Olafadehan, O. A. and Adewumi, M. K. 2009. Productive and reproductive performance of strategically supplemented free grazing prepartum Bunaji cows in the agropastoral farming system. Tropical Animal Health and Production. 41(7): 1275-1281.

Poore, M. H., Moore, J. A., Swingle, R. S., Eck, T. P. and Brown, W. H. 1993. Response of lactating Holstein cows to diets varying in fiber source and ruminal starch degradability. Journal of Dairy Science. 76: 3152-3159.

SAS 1999. SAS/STAT. User's guide version 8 for windows. SAS Institute Inc. Cary, NC: USA.

Schroeder, J. W. 2003. Optimizing the level of wet corn gluten feed in the diet of lactating dairy cows. Journal of Dairy Science. 86: 844–851.

Svennersten-Sjaunja, K., Sjaunja, L.O., Bertilsson, J. and Wiktorsson, H. 1997. Use of regular milking records versus dairy records for nutrition and other kinds of management. Livestock Production Science. 48: 167-174.

VanBaale, M. J., Shirley, J. E., Titgemeyer, E. C., Park, A. F., Meyer, M. J., Lindquist, R. U. and Ethington, R. T. 2001. Evaluation of wet corn gluten feed in diets for lactating dairy cows. Journal of Dairy Science. 84: 2478–2485.

Varga, G. A. and Ishler, V. A. 2008. Managing Nutrition for Optimal Milk Components. Retrieved from www.extension.org/pages/Managing_Nutrition_for_Optimal_Milk Components.

Van Soest, P. J., Robertson, J. B. and Lewis, B. A. 1991. Methods of dietary fibre, neutral detergent fibre and non-starch polysaccharides determination in relation to animal nutrition. Journal of Dairy Science. 74: 3583-3593.

Yu, P., Huber, J. T., Santos, F. A. P., Simas, J. M. and Theurer, C. B. 1998. Effects of ground, steamflaked, and steam-rolled corn grains on performance of lactating cows. Journal of Dairy Science. 81: 777-783.

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