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Effects of Protein Supplementation During the Dry Season on Feed Intake and Performance of Borgou Cows in Benin Republic

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Abstract: The purpose of this study was to assess the effect of dry season protein supplementation of Borgou cows on feed intake, milk production, body weight and calves growth performance. Animals (24 cows) were all given a basal diet of straw bush *ad libitum*. Cows of 1st group (8 cows in each group) were complemented with a concentrate CC (50% dried brewer's grains, 30% cassava chips, 15% dried cassava leaves, 2.5% dicalcium phosphate, 1.5% sodium chloride and 1% premix). Those of 2nd and 3rd groups received, respectively the concentrates CSC and SBM with the same composition as CC except that 20% of cassava chips were replaced by cottonseed cake in CSC and soybean meal in SBM. Protein supplementation had a significant effect ($p<0.05$) on straw bush voluntary ingestion (6.0 vs. 8.6 vs. 8.7 kg DM day^{-1}), daily milk yield (2.8 vs. 4.1 vs. 4.2 kg), cows weight gain (13 vs. 49 vs. 51 g day^{-1}), calves weight gain (131 vs. 170 vs. 179 g day^{-1}) and cost of feed per kg of milk (101 vs. 86 vs. 99 XOF). By cons, milk chemical composition was not affected ($p>0.05$).

Key words: Feed intake, cottonseed cake, soybean meal, milk yield, borgou, Benin Republic

INTRODUCTION

Dairy production in Benin relies on native cattle breeds, among which the Borgou cattle. This breed accounts for 88% of Benin's cattle population which is estimated at 1,954, 250 head (FAO, 2009). Milk production reaches 82.76 million litre year^{-1}, equivalent to 13 l per capita (Senou *et al*., 2008). At the same time, the population growth (3.2% per year) and urbanization increase the demand for milk and milk products. These figures show that the milk supply in Benin is much lower than the human population demand. It is therefore, necessary to increase productivity of dairy cattle in the country. The production system is a traditional low input system involving extensive grazing on natural pasture without supplementation. Natural forage is not sufficient to satisfy animal requirements in the dry season when the quantity decreases by 25-50% of peak biomass and nitrogen content falls well below 1% (Ayantunde, 1998). It is also deficient in readily fermentable energy, minerals and vitamins and cannot provide for optimum microbial growth in the rumen or tissue development of the host. As a result, growth rates and milk production are generally low and often only about 10% of the genetic potential of the animal (Leng, 1995). This study was therefore, designed to examine the effects of dry season protein supplementation with agro-industrial by-products on feed intake, milk production and body weight of Borgou cows and determine the economic benefits of protein supplementation of agropastoral herds.

MATERIALS AND METHODS

Study area: The experiment was conducted at Fana Fulani camp located in Gogounou district (Long. E 2°85' and Lat. N 9°43'). The climate is continental Sudanian with a dry season from October to April and a rainy season from May to November. The average rainfall is 1050 mm year^{-1} and the mean annual temperature ranges between 25 and 30°C. The vegetation consists of wooded or shrubby savannas and old fallows overgrown by various graminaceous formations.

Experimental animals and design: Twenty four dual purpose Borgou cows (2nd and 4th lactation) in early lactation with average weight of 253±54 kg were used for the experiment. Before the start of the trial, they were dewormed with albendazole and vaccinated against pasteurellosis and contagious bovine pleuropneumonia. The cows were balanced for weight and parity (lactation number) and separated into 3 groups of 8 cows each. The groups were randomly assigned to 3 treatments (A, B and C) in a complete randomized design.

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Table 1: Ingredient mixtures (%) of concentrates CC, CSC and SBM and chemical composition (DM%) of experimental feeds

Items	BS	CC	CSC	SBM
Dried brewery's grain	-	50.0	50.0	50.0
Cassava chip	-	30.0	10.0	10.0
Dried cassava leave	-	15.0	15.0	15.0
Cottonseed cake	-	-	20.0	-
Soybean meal	-	-	-	20.0
Dicalcium phosphate	-	2.5	2.5	2.5
Salt	-	1.5	1.5	1.5
Premix	-	1.0	1.0	1.0
Chemical composition				
Dry Matter (DM) (%)	93.7	90.6	90.6	90.5
Ash	7.8	11.2	12.3	11.9
Organic matter	92.2	88.8	87.7	88.1
Nitrogen free extract	45.2	54.6	42.9	43.4
Crude fibre	44.3	13.3	14.8	14.2
Crude protein	1.8	16.6	25.7	26.0
Digestible protein	0.0	11.6	17.4	17.8
Ether extract	0.9	4.3	4.3	4.5
Net energy (MJ kg^{-1} DM)	1.9	5.4	5.0	5.1

Feed and feeding: Groups of animals were given a basal diet of Bush Straw (BS) *ad libitum*. In addition to this basic diet, cows under treatments A, B, C were supplemented, respectively with concentrates CC, CSC and SBM. Ingredients composition of this concentrates are shown in Table 1. The concentrates were fed individually in two meals during morning and afternoon milking times. The experimental diets were prepared based on the following parameters: Average weight, level of production (estimated at 4 kg of milk per day to 4% fat), nutritional value of feed and feed intake capacity according to the weight of the animals. The experimental period lasted for 90 days. The first 20 days of the experiment was for adaptation of the cows to the new diets and the recording period of each treatment was 70 days. The cows had free access to clean water and mineral blocks all the time.

Milking procedure: Milk production records began 20 days after calving and hand milking was done twice a day (6:30 am and 6:00 pm). Calves were allowed to suck for about 1 min in order to stimulate milk let down. They were then tied in front of their dams while cows were hand milked. Partial milking was done in order to reserve milk for sucking calves which were prevented from sucking the dams. After milking, calves were allowed to resuckle their respective dams for 30 min. The daily milk offtake (i.e., extractable milk for human consumption) was taken at 10 days intervals and was weighed using a balance (100 g sensitivity). Estimated Milk Yield (MY) was calculated from the sum of the Milk Offtake (MO) and Calf's Growth (CG)×9 (Agyemang *et al*., 1993). Calf's growth×9 gave the estimate of the milk consumed by the calves:

$$MY = MO + (CG \times 9)$$

Data collection and chemical analysis: The age of cows was determined by dental timing (Lhoste *et al*., 1993) and body weight was estimated using a weight-band (Symoens and Hounsou-Ve, 1991) at the beginning and the end of the experimental trial. The feed intake was determined by weighing daily feed offered and refused. Samples of BS, CC, CSC and SBM and refusals were analyzed for Dry Matter (DM), Crude Protein (CP), Crude Fibre (CF), Ether Extract (EE) and ash using procedures described by AOAC (1990). Net energy content in Mega-Joule (MJ) of BS was determined using the Netherlands tables (Riviere, 1991). The content of BS in Digestible Protein (DP) was estimated using the following equation (Riviere, 1991):

$$DP (\%) = CP (DM\%)-4.5$$

Determination of net energy (MJ) and DP contents of concentrates was based on the equations fitted by Riviere (1991) for concentrate mixture:

$$MJ = OM \times d \times c/1000$$

$$DP = CP \times d$$

The d coefficient of digestibility of Organic Matter (OM) and CP. It is determined based on the content of the feed CF in a table (Riviere, 1991). The c coefficient which is determined according to d and the EE content of feed in a table (Riviere, 1991).

Calf weight was determined at the beginning and the end of the recording period and at the age of 1, 2 and 3 months by means of spring balances of 10-100 kg load capacity. During the experimental period, a total of 144 fresh milk samples were collected at 10 days intervals from 3 cows (randomly selected) per group from morning and evening milking. Composite morning and evening milk samples were kept overnight in a refrigerator maintained below 4°C and analyzed for fat, protein and total solids using the procedures of AOAC (1990).

Statistical analysis: Data collected on dry matter intake, milk yield, milk composition and cows live weight were subjected to statistical analysis using the ANOVA procedure of the Statistical Analysis System SAS® (SAS, 2003). Means were separated using the LSD test. Calves live weight and Average Daily weight Gain (ADG) were analysed using the GLM procedure (SAS, 2003).

Economic evaluation: Simple calculations were performed to determine the relative economics of supplementation with concentrates CC, CSC and SBM. The cost of the feeds consumed by the animals throughout the recording period of the trial was computed for each cow. While the feed was costed at the prevailing market prices, milk was priced using the producers' prices in order to quantify the net benefits from the feeding intervention.

RESULTS AND DISCUSSION

Bush Straw (BS) had high CF content and low net energy and CP contents (Table 1). The CP content (18 g kg^{-1} DM) allows classifying the BS as poor quality forages whose CP content does not exceed 80 g kg^{-1} DM (Leng, 1990). BS certainly has a low nutritional value but it is often the only forage available during the dry season for traditional cattle herds (Senou *et al*., 2008). The three concentrates (CC, CSC and SBM) had close net energy and DM contents but different CP content: concentrate CC content lower CP than concentrates CSC and SBM (Table 1). Net energy content of diets B and C was higher ($p<0.05$), respectively of 17.5 and 20.2% compared to diet A (Table 2). Protein content of diets B and C was also higher ($p<0.05$) by 46.8 and 51.6%, respectively. Cows in treatments B and C received all nutrients in excess ($p<0.05$) compared to those in treatment A (Table 2). The proportion of concentrate in the diet A was greater ($p<0.05$) than that of diet B and C. The DM intake of the cows in treatment A is close to the value of 7.9 kg DM day^{-1} reported by Senou *et al*. (2008) at the ranch of Okpara in Benin Republic. Protein supplementation during the dry season had a significant ($p<0.05$) effect on feed and nutritient intake by experimental cows (Table 2). Voluntary intake of concentrate was similar ($p>0.05$) for the 3 treatments. By cons, voluntary intake of BS was different ($p<0.05$): cows on treatment A ingested less ($p<0.01$) BS than cows in treatment B and C. This may be due to nitrogen deficiency because cows in treatment A received only 58 g kg^{-1} DM of CP vs. 87 and 89 g kg^{-1} DM, respectively for cows in treatment B and C. According to Malafaia *et al.* (2003) when CP content is <60-70 g kg^{-1} DM, the DMI will be reduced due to nitrogen deficiencies. The results agreed with Church and Santos (1981), Guthrie and Wagner (1988) and Chenost and Kayouli (1997) whereby the protein supplementation promotes the increase in DMI of forages. Two hypotheses have been proposed to explain this response. One suggested that additional protein sources enhance ruminal bacterial activity (Garza *et al*., 1991). The other hypothesis stated that dietary protein has an effect on ruminal motility and rate of passage (Kil and Froetschel, 1994). Feed intake can be maximum if with an adequate supply of nitrogen, a limited amount of carbohydrates is provided (Barry and Johnstone, 1976). The addition of beet pulp increased feed intake of untreated straw in sheep and cattle (Silva *et al*., 1989) due to the increase in the rate of degradation of straw in the rumen (Silva and Orskov, 1988). Forage digestibility can be increased by protein supplementation (Corbett, 1981). Redman *et al*. (1980) reported that supplementation of oaten chaff diets with urea or casein increased digesta flow. Moreover, Corbett (1981) indicated that protein supplements increased forage intake by increasing ruminal digesta turnover.

However, protein supplementation did not alter particulate retention time in steers grazing dormant rangeland (Judkins *et al*., 1987).

Protein supplementation had a significant effect ($p<0.05$) on the daily milk offtake and the daily suckled milk, resulting in an increase ($p<0.05$) daily milk yield and total milk yield of Borgou cows (Table 3). The deviations from treatment A were 43.3 and 50.3% for treatments B and C, respectively. Similar results also reported by Dejene *et al*. (2009) indicated that crossbred dairy cows fed a basal diet of urea treated teff straw supplemented with linseed cake based concentrate mixture had a significantly higher milk yield than for control animals.

Table 2: Dry Matter (DM) and nutrient intakes (kg day^{-1}) by Borgou cows supplemented with concentrates CC, CSC and SBM

Parameters	A	B	C
Bush straw (DM)	5.95±0.76[a]	8.64±0.31[b]	8.74±0.86[b]
Concentrate (DM)	2.20±0.28[a]	2.15±0.08[a]	2.16±0.21[a]
Total DM	8.15±1.04[a]	10.78±0.39[b]	10.91±1.07[b]
Ash	0.71±0.09[a]	0.94±0.04[b]	0.95±0.09[b]
Organic matter	7.44±0.95[a]	9.85±0.36[b]	9.97±0.98[b]
Nitrogen free extract	3.89±0.50[a]	4.82±0.18[b]	4.89±0.48[b]
Crude fibre	2.93±0.37[a]	4.15±0.15[b]	4.18±0.41[b]
Crude protein	0.47±0.06[a]	0.71±0.03[b]	0.72±0.07[b]
Digestible protein	0.26±0.03[a]	0.37±0.01[b]	0.39±0.04[b]
Ether extract	0.15±0.02[a]	0.17±0.01[b]	0.18±0.02[b]
Net energy (MJ day^{-1})	23.19±2.97[a]	27.15±0.96[b]	27.65±2.72[b]
Percentage of concentrate in the diet	27.10±1.30[a]	19.90±0.90[b]	19.80±1.40[b]

[a-c]Means with different superscript letters on the same row differ significantly ($p<0.05$); A = BS+CC; B = BS+CSC; C = BS+SBM

Table 3: The effects of treatments on milk yield, composition and weight gain of milking Borgou cows

Parameters	A	B	C
Milk production (kg)			
Daily milk offtake	1.51±0.18[b]	2.44±0.09[a]	2.53±0.25[a]
Daily suckled milk	1.28±0.16[b]	1.63±0.11[a]	1.71±0.12[a]
Daily milk yield	2.79±0.34[b]	4.07±0.13[a]	4.24±0.36[a]
Total milk yield	195.30±24.1[b]	284.80±9.10[a]	296.5±24.90[a]
Milk composition (%)			
Fat	5.17±0.37[a]	4.95±0.29[a]	5.07±0.24[a]
Protein	3.92±0.34[a]	4.03±0.24[a]	4.12±0.36[a]
Total solids	13.95±0.41[a]	13.48±0.46[a]	13.27±0.18[a]
Body weight (kg)			
Initial weight	253.20±31.9[a]	255.20±9.10[a]	251.70±24.6[a]
Final weight	254.40±31.4[a]	259.50±8.60[a]	256.40±23.9[a]
Body weight change	1.20±0.60[b]	4.40±0.60[a]	4.60±0.70[a]
Weight gain (g day^{-1})	13.40±6.20[b]	48.80±6.40[a]	51.30±7.50[a]

[a-c]Means with different superscript letters on the same row differ significantly ($p<0.05$)

Table 4: Least-squares means of live body weight and Average Daily body weight Gain (ADG) of calves at different ages

		Treatments			Sex	
Parameters	Overall mean±SD	A	B	C	F	M
Body weight at (kg)	(24)	(8.00)	(8.00)	(8.00)	(11.00)	(13.00)
Birth	18.89±1.87	18.91[a]	18.80[a]	18.95[a]	19.01[a]	18.78[a]
30 days	23.03±2.24	22.19[a]	23.25[a]	23.66[a]	23.08[a]	22.99[a]
60 days	28.88±2.84	26.99[b]	29.48[ab]	30.19[a]	28.84[a]	28.92[a]
90 days	33.30±3.43	30.74[b]	34.11[a]	35.06[a]	33.21[a]	33.38[a]
ADG (g day^{-1})	(24)	(8.00)	(8.00)	(8.00)	(11.00)	(13.00)
0-30 days	138.2±24.2	109.20[b]	148.30[a]	157.10[a]	135.80[a]	140.30[a]
30-60 days	195.0±31.2	160.00[b]	207.50[a]	217.50[a]	191.80[a]	197.70[a]
60-90 days	147.4±21.3	125.00[b]	154.60[a]	162.50[a]	145.70[a]	148.70[a]
0-90 days	160.2±24.2	131.40[b]	170.10[a]	179.00[a]	157.80[a]	162.20[a]

Values in bracket are number of observations; F = Female, M = Male; [a-c]Least-squares means with different superscript letters on the same row differ significantly ($p<0.05$)

Table 5: Comparative cost advantage of protein supplementation of milking Borgou cows. Cost expressed in XOF

	Treatments		
Parameters	A	B	C
Cost per kg concentrate	104	126	154
Total concentrate consumed (kg)	170.1±20.3[a]	165.9±5.6[a]	167.3±15.3[a]
Cost of feeding, XOF/cow	19912±2544[c]	24129±871[b]	29030±2848[a]
Total milk yield (kg)	195.3±24.1[b]	284.8±9.1[a]	296.5±24.9[a]
Cost of feed per kg of milk	100.5±0.2[a]	86.1±1.5[c]	98.6±0.1[b]
Value of milk yield (XOF*)	48815±6022[b]	71203±2269[a]	74115±6227[a]
Net benefit (XOF)	28903±3481[b]	47074±1942[a]	45085±3420[a]
Differential benefit (XOF)	-	18171	16182
Relative benefit (%)	-	62.9	56.0

*Based on the price of 250 XOF per kg of fresh milk

The milk yield obtained in the current study was higher than most reported milk yields for Borgou cows (Senou *et al*., 2008) and Bunaji cows (Agyemang *et al*., 1998; Olafadehan and Adewumi, 2008) under traditional husbandry conditions. No significant difference ($p>0.05$) was observed at the chemical composition of milk from cows under different treatments (Table 3). According to Coulon and Remond (1991), increasing CP in the diet leads to increased joint quantities of milk and secreted proteins so that the level of CP is not changed. Protein supplementation had no significant effect ($p>0.05$) on final body weight of Borgou cows (Table 3). However, the body weight change and weight gain were higher ($p<0.05$) in cows in treatment B and C compared to those in treatment A. Protein supplementation had enabled experimental cows to maintain their body weight during the harsh dry season. No significant effect ($p>0.05$) was observed on calves' weight at birth and 30 days of age (Table 4). Later at 60 and 90 days of age, the effect of protein supplementation was significant ($p<0.05$) and live weight of calves whose dams were subjected to treatments B and C was higher ($p<0.05$) compared to treatment A. The effect of protein supplementation on calves weight gain was significantly ($p<0.05$) throughout the trial period (Table 4). Calves whose dams were subjected to treatments B and C had higher ($p<0.05$) weight gains compared to treatment A. The sex of the calves had no significant effect ($p>0.05$) on their weight or weight gain at different ages studied (Table 4). The results are lower than those obtained by Alkoiret *et al.* (2010) on calves Borgou in traditional breeding in northern Benin (234 g day^{-1} for females and 227 g day^{-1} for males) and Youssao *et al.* (2000) at the ranch of Okpara, Benin (214 g day^{-1} for females and 229 g day^{-1} for males). In both researches, the measurements were made during the rainy season which explains their superiority.

Concentrate SBM was the most expensive followed by CSC while CC was less expensive (Table 5). Cows subjected to treatment A had the lowest ($p<0.05$) feed cost followed by those in treatments B and C. By cons, the lowest ($p<0.05$) feed cost per kg of milk produced was recorded in cows on treatment B followed by those in treatment C (Table 5). Protein supplementation had a significant effect ($p<0.05$) on the profitability of the operation. The result is in line with the findings of Agyemang *et al.* (1998), Olafadehan and Adewumi (2008) and Dejene *et al.* (2009).

CONCLUSION

This study showed that protein supplementation had an impact on zootechnical performance of Borgou cows during the dry season. The cows ingested more BS DM and gave better milk production while the chemical composition of milk was not affected. Protein supplementation resulted Borgou lactating cows to maintain their body weights during the harsh dry season and to improve the performance of weight gain of their calves. The concentrate containing cottonseed cake gave the best economic result given the purchase price is lower than soybean meal. This study should be continued in the direction of the search for cheaper sources of nitrogen that can fill the gap in forage crude protein during the dry season.

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