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Effect of Varying Levels of Whole Cottonseed Supplementation on Concentrate Intake, Weight Gain and Blood Parameters in Friesian×Bunaji and Bunaji Heifers

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Abstract: A study was carried out to determine the effects of varying levels of whole cottonseed on feed intake, weight gain and blood parameters in Friesian×Bunaji and Bunaji heifers. Twenty Friesian×Bunaji and 24 Bunaji pre-pubertal heifers were divided to 4 groups of 5 and 6 animals/group. Animals in each group were fed 1 of 4 experimental concentrate diets containing 0, 25, 50 and 75% whole cottonseed for 140 days. The result of the study showed that concentrate intake declined with increase in the level of whole cottonseed in dieting averaging 4.2, 3.3, 3.1 and 2.9 kg head $^{-1}$day $^{-1}$ in Friesian×Bunaji fed 0, 25, 50 and 75% whole cottonseed diets, respectively. The corresponding intake figures for the Bunaji heifers were 3.1, 2.9, 2.5 and 2.2 kg head $^{-1}$ day $^{-1}$. Mean daily weight gain were 0.59, 0.59, 0.48 and 0.64 kg in Friesian×Bunaji and 0.48, 0.41 and 0.50 C kg in Bunaji heifers fed 0, 25, 50 and 75% whole cottonseed levels, respectively. Changes in blood parameters were not significant in both Friesian×Bunaji and Bunaji heifers across treatments. The study showed that heifers could be fed diets containing up to 75% whole cottonseed, respectively without adverse effects.

Key words: Whole cottonseed, concentrate intake, performance, heifers

INTRODUCTION

Studies have shown that the time taken by an animal to reach puberty and sexual maturity depends on availability and quality of feed (Oyedipe *et al*., 1982a; Mukasa-Mugerwa, 1989). A way of reducing the costs of raising heifers is by feeding diets that will stimulate faster growth rates and reduce age at first calving. Whole cottonseed is high in energy, protein and fibre and possesses the potential to induce growth (Arieli, 1998; Rogers *et al*., 2002). Despite these qualities, feeding whole cottonseed diets to livestock, especially monogastrics and young ruminants with undeveloped rumens has limited by its potential toxic effect due to the presence of gossypol. Even with adult female ruminants, which have been reported to exhibit limited signs of gossypol toxicity (Rogers *et al*., 2002); caution is often exercised when feeding whole cottonseed. Reported previous studies on feeding whole cottonseed to cattle show variations in reported safe levels of whole cottonseed supplementation. Lanham *et al*. (1992) reported that diets containing 30% whole cottonseed were not toxic to growing cattle; however, a sharp decline in dry matter intake occurred as whole cottonseed levels increased from 35 to 55%. Poore (1994) recommended that for first parity cows a grain diet should be fed alongside whole cottonseed. Arieli (1998) suggest that whole cottonseed should be fed at 10 to 15% of the total diet DM for dairy cattle. Rogers *et al*. (2002) suggested that whole cottonseed could be fed at about 0.33% of body weight or 15% of the total ration to growing cattle.

The objective of this study was to determine the effects of feeding concentrate diets with varying levels of whole cottonseed on feed intake, weight gain and blood parameters of prepubertal heifers.

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MATERIALS AND METHODS

Study Site

The study was carried out at the Dairy Research Programme farm of the National Animal Production Research Institute, Ahmadu Bello University, Shika-Zaria, Nigeria. Shika lies between Latitudes 11 and 12° North and between Longitude 7 and 8° East. Mean annual rainfall in the area is 1100 mm, lasting from May to October. Mean relative humidity is about 72%, while the average daily temperature is about 25°C. The wet season is followed by a dry period (dry season), which lasts from November to April, with mean daily temperatures ranging from 14-36°C and mean relative humidity between 20 and 37%.

Experimental Animals and Their Management

The experimental animals consisted of 20 Friesian×Bunaji and 24 Bunaji prepubertal heifers. The Friesian×Bunaji prepubertal heifers were born on station, while the Bunaji heifers were purchased from the open market. The ages and initial weights of Friesian×Bunaji heifers ranged between 16 and 18 months and 180 and 220 kg, respectively. The ages of the Bunaji heifers were determined by an experienced veterinarian using the dentition (Forse, 1999) and ranged between 24 and 28 months. Their initial weights were between 140 and 180 kg. The experimental animals were dewormed with Albenda 2500® (Albendazole) bolus (Eagle Chemicals Co. Ltd. Chungchongnamdo, Korea) at the rate of 5 mg kg^{-1} body weight. They were treated against ticks and other ectoparasites by twice weekly dipping in a long-walk dip containing Steladone® (Novartis Inc. Basle, Switzerland).

Experimental Feed and Feeding

Four concentrate diets were formulated to contain 0, 25, 50 and 75% whole cottonseed (Table 1). The diet with 0% whole cottonseed served as the control. The animals were divided within breeds into 4 groups of 5 and 6 animals per group for Friesian×Bunaji and Bunaji, respectively. They were weighed and after balancing for weight each group within breed was randomly assigned to one of four experimental diets in a randomized complete block design. They were taken through a 14 day pre-experimental period followed by a 7 day adjustment period. The animals were fed the control diet (0% whole cottonseed diet) and diets assigned to specific groups during the pre-experimental and adjustment periods respectively at the rate of 1 kg $head^{-1}$ day^{-1}. After the adjustment period, they were weighed and the daily concentrate allowance adjusted to the experimental feeding rate of 1.5% of body weight $head^{-1}$ day^{-1}. Subsequently, concentrate allowance was adjusted fortnightly after the

Table 1: Composition of experimental diets (%)

Ingredients	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Whole cottonseed	0.000	25.000	50.000	75.000
Cottonseed cake	48.000	0.000	0.000	0.000
Wheat bran	13.700	49.300	27.300	11.600
Maize	35.300	22.700	19.700	10.400
Bone meal	2.000	2.000	2.000	2.000
Table salt	1.000	1.000	1.000	1.000
Dry matter	96.000	96.100	96.200	96.700
Crude protein	16.000	15.400	16.300	17.800
Crude fibre	21.600	28.200	33.400	43.500
Ether extract	11.000	17.900	24.000	25.600
Neutral detergent fibre	23.400	34.500	34.600	34.800
Acid detergent fibre	24.100	28.700	31.600	41.400
Ash	11.000	10.500	6.800	6.500
ME (Kcal kg^{-1})	3063.700	2831.500	3397.500	3603.100
Estimated gossypol	0.033	0.289	0.577	0.866

ME: Metabolizable Energy, Estimated gossypol (kg kg^{-1})

animals had been weighed. The animals were individually fed the concentrate for 3 h in the morning (between 7.00-10.00 am) before going out for grazing from 10.00 am to 5.30 pm. The animals grazed on natural range throughout the experimental period. Concentrate intake was measured by weighing leftovers at the end of the 3 h feeding period. Body weight changes were determined by weighing the animals fortnightly. The trial lasted for 140 days.

Blood Parameters

Blood samples were drawn from the jugular vein of each animal into 10 mL blood sample tubes at the beginning of the study and subsequently at 2 weeks interval. Ethylene-di-amine-tetra-acetic acid (EDTA) was used as anticoagulant (5 mg $tube^{-1}$). The blood samples were used to determine packed cell volume, white blood cell count, haemoglobin, neutrophils and lymphocytes. All collected blood samples were processed within 2 h of collection.

Analytical Procedures

Feed samples were analysed for proximate components (AOAC, 1990) and for Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF), using the procedures of Goering and Van Soest (1970). The blood samples were used for the determination of packed cell volume, erythrocyte, white blood cell count and differential (neutrophile and lymphocyte) counts (Coles, 1974). The collected blood samples were processed within 2 h of collection.

Data Management and Analysis

Data collected were computed using Microsoft Excel software (Microsoft XP). The data were analysed using General Linear Model Procedures of the Statistical Analysis System (SAS, 1987) to study the effect of varying levels of whole cottonseed in the diets on the various parameters measured. The model used was:

$$Y_{ijk} = \mu + B_j + X_{ijk} + T_k + e_{ijk}.$$

Where,

Y_{ijk} = Record of dependent variable
μ = Overall mean
B = Block effect
X_{ijk} = Covariate effect
T_k = Treatment effect
e_{ijk} = Residual term.

All statistical tests were done at 1 and 5% probability levels.

RESULTS

Composition of Experimental Diets

Dry matter averaged 96.3% across diets, while crude protein levels averaged 16.0, 15.4, 16.3 and 17.8% for diets containing 0, 25, 50 and 75% whole cottonseed, respectively. Crude fibre content increased with increase in the level of whole cottonseed. Similarly, Ether extract, NDF and ADF increased with increase in the level of whole cottonseed in the diets. However, ash content declined as whole cottonseed increased in the diet (Table 1).

Feed Intake

Friesian×Bunaji heifers on diet containing 0% whole cottonseed had the highest average daily concentrate intake of 4.2 kg $head^{-1}$ day^{-1}, while those on 75% whole cottonseed diet had the least (2.9 kg $head^{-1}$ day^{-1}) (Table 2). The difference in the average concentrate intake by heifers on

Table 2: Effect of level of whole cottonseed on feed intake and weight gain by Friesian×Bunaji and Bunaji heifers

	Inclusion levels of whole cottonseed (%)									
	0		25		50		75			
Parameters	Frx	BJ	Frx	BJ	Frx	BJ	Frx	BJ	SEM	LOS
Total concentrate intake (kg)	593.200[a]	439.700[b]	462.500[a]	409.700[b]	430.600[a]	342.500[b]	407.600[a]	336.100[b]	3.100	**
Average concentrate (kg head^{-1} day^{-1})	4.200[a]	3.100[b]	3.300[a]	2.900[b]	3.100[a]	2.500[b]	2.900[a]	2.200[b]	0.200	**
Total weight gain (kg)	82.900[a]	66.900[b]	82.500[a]	57.700[b]	67.800[a]	66.700[b]	89.200[a]	69.300[b]	2.000	**
ADG (kg day^{-1})	0.592[a]	0.478[b]	0.589[a]	0.412[b]	0.484[a]	0.476[b]	0.637[a]	0.495[b]	0.025	**
Feed: Gain ratio	7.200[a]	6.600[a]	5.600[b]	7.100[a]	6.400[a]	5.100[b]	4.600[a]	4.800[a]	0.800	*

[ab]: Means within the same row in the same treatment column with different superscripts are significantly different. Frx = Friesian×Bunaji, BJ = Bunaji, LOS = Level of Significance, **: p<0.01, *: p<0.05

25 and 50% whole cottonseed diets (3.3 and 3.1 kg head^{-1} day^{-1}) was not significant. Concentrate intake was also depressed significantly (p<0.01) with increase in the level of whole cottonseed in the diets in the Bunaji heifers (Table 2). Animals on 50 and 75% whole cottonseed diets had significantly lower (p<0.05) concentrate intake compared to those on 0 and 25% whole cottonseed diets. There was no significant difference in concentrate intake between animals on 0 and 25% whole cottonseed diets and between those on 50 and 75% whole cottonseed diets. Within treatments, feed intake by Friesian×Bunaji heifers was significantly higher (p<0.01) than those of Bunaji heifers.

Weight Gain

Average daily weight gain by Friesian×Bunaji heifers fed 75% whole cottonseed diet (0.637 kg day^{-1}) was significantly higher (p<0.01) than those of heifers on the other treatments, while those of animals on 0 and 25% whole cottonseed diets were not significantly different (p>0.05) (Table 2). The least average daily weight gain (0.484 kg day^{-1}) was recorded in animals on 50% whole cottonseed diet. The difference in feed: gain ratio of animals fed 0 and 50% whole cottonseed diets was not significant. In terms of cumulative weight gains, Friesian×Bunaji heifers fed 25, 50 and 75% whole cottonseed diets performed better than those fed 0% whole cottonseed. The best performance was recorded in animals fed 75% whole cottonseed diet. Among the Bunaji heifers (Table 2) average total weight gained and average daily weight gains of animals fed 0, 25 and 75% whole cottonseed diets were not significantly different. Weight gain by Bunaji heifers fed the 50% whole cottonseed diet was significantly lower (p<0.05) than those fed the other diets. Feed: gain ratio varied significantly (p<0.05) across treatments. Bunaji heifers fed 25% whole cottonseed diets had significantly (p<0.01) higher feed: gain ratios than those fed the other diets. Feed: gain ratio of Bunaji fed 0% whole cottonseed diet was also significantly higher (p<0.01) than those of animals fed 50 and 75% whole cottonseed diets. Within treatments the differences in weight gains between Friesian×Bunaji and Bunaji heifers were highly significant (p<0.01) (Table 2). There was no significant difference in feed: gain ratio between Friesian×Bunaji and Bunaji heifers fed 0 and 75% whole cottonseed diets, but the ratios were significantly different (p<0.05) in those fed 25 and 50% whole cottonseed diets.

Haematological Changes

There were no significant differences in packed cell volume, haemoglobin, white blood cells, neutrophils and lymphocytes levels in the blood of Friesian×Bunaji heifers across treatments (Table 3). Packed cell volume, total white blood cells count and neutrophils levels were not significantly different in Bunaji heifers fed 0, 25 and 50% whole cottonseed diets (Table 3). The values increased significantly (p<0.05) in those fed 75% whole cottonseed diet. There were no significant differences in Haemoglobin and lymphocytes concentrations across treatments. Within treatments,

Table 3: Haematological changes in pre-pubertal Friesian×Bunaji and Bunaji heifers fed varying levels of whole cottonseed

	Inclusion levels of whole cottonseed (%)									
	0		25		50		75			
Parameter	Frx	BJ	Frx	BJ	Frx	BJ	Frx	BJ	SEM	LOS
Packed cell volume (%)	30.2[a]	29.3[a]	29.6[a]	29.8[a]	29.4[a]	29.7[a]	29.2[b]	33.7[a]	1.5	*
Haemoglobin (g 100^{-1} mL)	10.1	10.0	10.2	10.3	10.5	10.1	9.8	10.0	0.5	ns
White blood cells ($\times 10^6$)	11.0[a]	9.9[a]	9.9[a]	9.8[a]	10.3[a]	10.5[a]	10.5[b]	12.7[a]	0.8	*
Neutrophils (%)	21.0[a]	26.8[a]	27.6[a]	24.0[a]	27.0[a]	28.8[a]	26.4[b]	33.8[a]	3.7	*
Lymphocytes (%)	79.0	79.2	71.4	72.7	79.0	72.4	73.6	69.7	4.1	ns

[ab]: Means within the same row in the same treatment column with different superscripts are significantly different. Frx = Friesian×Bunaji, BJ = Bunaji, LOS = Level of Significance, *: $p<0.05$, ns: Non significant

there were no significant differences in packed cell volume, haemoglobin, total white blood cells and neutrophils concentrations in the blood of Friesian×Bunaji and Bunaji heifers fed 0, 25 and 50% whole cottonseed diets (Table 3). Packed cell volume, haemoglobin, total white blood cells and neutrophils were significantly ($p<0.05$) higher in Bunaji heifers fed 75% whole cottonseed diet than in the Friesian×Bunajiheifers fed the same diet. Lymphocyte concentrations were not significantly different in Friesian×Bunajiand Bunaji heifers across treatments.

DISCUSSION

The increase in ether extract, NDF and ADF in the diets with increase in the level of whole cottonseed in the diet, is as expected, because of the high amounts of these components in the whole cottonseed (NRC, 1989; Bernard *et al*., 1999). Whole cottonseed used in this study was highly linted, accounting for the increase in the fibre content of the feed with increase in whole cottonseed. Holland and Jaster (1999) and Mujahid *et al*. (2000) reported that the amount of lint on the seed varies with cotton variety and the efficiency of delinting process and this often affects the fibre content.

The general decline in feed intake in both Friesian×Bunaji and Bunaji heifers with increase in the level of whole cottonseed observed in this study agrees with the reports of Lanham *et al*. (1992). However, the results is at variance with that of Harvatine *et al*. (2002) who reported significant increases in dry matter intake with increase in the proportion of dietary whole cottonseed. The significant difference in concentrate intake between the Friesian×Bunaji and Bunaji heifers within the same treatment diet could be attributed to the fact that the Friesian×Bunaji being of a bigger frame consumed more feed to maintain their larger body mass.

The fact that whole cottonseed constituted the largest component of the rejected feed, as the level of its inclusion in the diet increased, is an indication that the animals selectively ingest other component of the feed while rejecting whole cottonseed. This preferential consumption of other ingredients in the diets resulted in large leftovers, which might have been reflected in the decline in total feed intake with increase in the level of whole cottonseed. Highly linted whole cottonseed as was used in this study had been implicated in observed depression in dry matter intake (Lanham *et al*., 1992; Arieli, 1998; Harvatine *et al*., 2002). Arieli (1998) observed that highly linted whole cottonseed usually stratifies in the ruminal contents. It is possible that gut fill was increased with increase in the rate of stratification of whole cottonseed in the rumen as more linted whole cottonseed was consumed causing a decline in dry matter intake. It is also possible that the increase in both ether extract and neutral detergent fibre with increase in whole cottonseed could have contributed to the depressed feed intake since supplemental fats/oil has been associated with depression of feed intake (Harrison *et al*., 1995;

Choi *et al*., 1996; Romo *et al*., 1996). Similar negative effect of whole cottonseed on dry matter intake of goats has been reported by Luginbuhl *et al*. (2000) and was attributed to the increase in dietary Ether Extract (EE) and Neutral Detergent Fibre (NDF) with increase in whole cottonseed levels in the diets.

The significant difference in growth rate between Friesian×Bunaji and Bunaji heifers within treatments is similar to what had been reported by Rekwot (2000). The higher weight gains of both Friesian×Bunajiand Bunaji heifers fed the diet with 75% whole cottonseed compared to other treatments is consistent with the reports of Van Amburgh *et al*. (1998) and Firkins *et al*. (2002), which showed increases in body weight gains at high levels of whole cottonseed. Arieli (1998) and Rogers *et al*. (2002) attributed the improved performance of cattle fed high whole cottonseed diets to the high energy and protein content of whole cottonseed. The decline in feed: gain ratio in both breeds at high whole cottonseed levels may probably indicate a possible improvement in feed efficiency with increase in whole cottonseed in the diet.

The increase in total white blood cells and neutrophiles in the Bunaji fed the 75% whole cottonseed diet agrees with the findings of Coppo *et al*. (1994). Packed cell volume, total white blood cells count and neutrophiles of Bunaji heifers on 75% whole cottonseed diet were significantly higher than those Friesian×Bunaji heifers on the same diets. These results seem to suggest that the Bunaji heifers were less adversely affected by high level of whole cottonseed than the Friesian×Bunajiheifers. However, for both Friesian×Bunaji and Bunaji heifers, the values for packed cell volume, haemoglobin and white blood cell count remained within normal ranges (26-42%, 8-14 g 100^{-1} mL and 9-12×10^{3} 100^{-1} mL, respectively) for cattle (Coles, 1974; Olaloku and Oyenuga, 1975) even at high levels of whole cottonseed. These findings also agree with those of Hawkins *et al*. (1985) and Barraza *et al*. (1991) who reported no change in the blood metabolites even when whole cottonseed was fed at levels considered to be toxicity threshold. The result also confirms the ability of ruminants with fully developed rumen to tolerate high levels of whole cottonseed intake (Risco *et al*., 1993; Calhoun *et al*., 1996; Mena *et al*., 2001).

CONCLUSIONS AND RECOMMENDATIONS

From the results off this study it could be concluded that increase in the level of whole cottonseed in the diets of prepubertal heifers depressed feed intake significantly. Weight gain by both Friesian×Bunaji and Bunaji heifers increased with increase in the level of whole cottonseed in the diet. Level of whole cottonseed supplementation had no significant effect on values of blood parameters. It is suggested that prepubertal heifers could be fed diets with up to 75% whole cottonseed without exhibiting any toxicity signs on the parameters investigated.

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