Nigerian Veterinary Journal 27(3) : 36 - 45

EFFECT OF FEEDING DIFFERENT LEVELS OF WHOLE COTTONSEED ON PERFORMANCE OF WEANED CALVES

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SUMMARY

A study was carried out to examine the effects of feeding varying levels of whole cottonseed on the performance of weaned calves. Twenty Friesian x Bunaji heifers and eight bull calves, age between 5 and 6 months, and weighing between 100 and 170kg were fed four concentrate diets formulated to contain 0, 25, 50 and 75% whole cottonseed, to determine the effect of level of whole cottonseed on their performance. The result of the study shows that concentrate intake by calves was significantly higher in calves fed 0 and 25% than in 50 and 75% whole cottonseed diets. Daily weight gains averaged 0.87, 0.45, 0.35 and 0.21 kg for the calves fed 0, 25, 50 and 75% whole cottonseed diets, respectively. Changes in blood parameters were not significant (P>0.05) in across treatments. Dry and organic matter digestibilities declined with increase in the level of whole cottonseed in the diet. Crude protein, acid detergent fibre, neutral detergent fibre, and ether extract digestibilities increased with increase in the level of whole cottonseed. The study shows that calves could be fed diets containing up to 25% without adverse effects.

KEY WORDS: Whole cottonseed, Growth, Blood profile, Calves

INTRODUCTION

Whole cottonseed has been described as a unique feedstuff and a multi-nutrient supplement, which supplies high energy, digestible fibre, protein and phosphorus in greater concentrations than is required in the total diet of high yielding dairy cows (Coppock et al. 1987; Bernard, 1999, Rogers et al. 2002). Despite these qualities, feeding whole cottonseed diets to growing cattle is done with some reservation because of conflicting reports on the levels of inclusion in the diet that could be toxic to calves. Anderson et al. (1982) fed concentrate containing 25% whole cottonseed (with and without hay) to newborn calves and reported greater feed intake, body weights, and rumen development at 12 weeks than those not fed whole cottonseed. Rogers et al. (2002) suggested that growing cattle could be fed whole cottonseed at about 0.33% of body weight or 15% of the total ration. However, Poore (1994) recommended that for first calf heifers a grain supplement should be included in the diets with up to 15% whole cottonseed levels to meet their requirements. The current study was carried out to examine the effects of feeding diets with different levels of whole cottonseed on the performance of weaned calves.

MATERIALS AND METHODS

Animals and treatments

Twenty Friesian x Bunaji (50:50) crossbred heifer and eight bull calves, aged between 5 and 6 months and weighed between 100 and 170kg were used in this study. The calves were weighed at the beginning of the experiment and divided into 4 groups of 5 animals each. After balancing for weight, the groups were randomly assigned to four experimental diets (treatments) in a randomized complete block design. The animals were housed in roofed individual pens throughout the experimental period.

Experimental diets and feeding

Four iso-nitrogenous concentrate diets formulated to contain 16 percent crude protein were used (Table 1) in this study. Whole cottonseed was incorporated in the concentrates at 0, 25, 50 and 75 percent levels. All the animals were allowed a 14-days standardization period prior to feeding of the experimental diets. During the standardization they were fed the control concentrate diet daily at the rate of 1kg/head/day. The calves were allowed 24 hours access to the concentrate at the end of which left over was weighed and a fresh supply of feed offered. At the end of the standardization period the calves were weighed and the groups randomly assigned to the treatments (0, 25, 50 and 75% whole cottonseed diets). A further 14-days adjustment period was allowed during which they were fed the experimental diet assigned to that group at 1kg/head/day. Thereafter they were weighed and each fed the respective concentrate at the rate of 1.5% body weight. Subsequently the amount of concentrate offered was adjusted fortnightly on the basis of animal weight. The concentrate diets were compounded fortnightly. In addition to the concentrates the calves were allowed *ad lib* access to hay (*Digitaria smutsii.*) as the basal feed and clean drinking water. The study lasted for 140 days. During the 140 days experimental period, feed intake was measured daily and the animals weighed fortnightly.

Blood Parameters and metabolites

Jugular blood samples (5ml) were drawn from each animal into test tubes at the beginning of the study and subsequently at 2 weeks interval. Ethylene-di-amine-tetra-acetic acid (EDTA) was used as anticoagulant (5mg/tube). The blood samples were used for the determination of packed cell volume, erythrocyte, white blood cell count, and differential (neutrophile and lymphocyte) count. The collected blood samples were processed within 2 hours of collection.

Digestibility study

At the end of the feeding trial, eight bull calves were weighed and blocked into 4 groups of 2 each and groups randomly assigned the same experiment diets as used in the feeding trial. The animals were confined in individual metabolism crates, and allowed a 14-days adjustment period during which they were fed 1kg/head/day of the diet allocated to each group. This was followed by a 7-days digestibility study when they were fed the experimental diet at 1.5% body weight/head/day. The daily ration was split into two and fed at 7.00 am and 3.30 pm. In addition the animals were allowed *ad lib* access to water and *Digitaria smutsii* hay. Leftover of feed and

hay were weighed and recorded daily before the morning feeding. During the 7-days experimental trial, grasp samples of the total daily faeces voided were stored in the refrigerator. At the end of the collection period, the faecal samples from each bull were bulked and mixed thoroughly and 10% of it was taken and oven dried at 60°C for 2 days. The oven dried faecal samples were again bulked, mixed thoroughly and 10% of mixed samples taken for proximate analysis. Daily urine output from each bull was collected in plastic containers containing 100 ml 0.1N H_2SO_4 placed under the metabolism crates. Daily 10% of the urine collected from each bull was taken and stored in a refrigerator. At the end of the collection period, urine samples from each bull were bulked together and 10% taken and kept in a refrigerator until required for analysis (Osuji et al., 1993). Equal quantities of the experimental feed, hay and feed leftover were taken daily, mixed thoroughly and sub sampled at the end of the collection period. The samples were then milled to pass through a 1mm mesh sieve and stored in airtight bottles for analysis.

Analytical procedures

Feed, hay and faecal samples were analysed for proximate components (AOAC, 1980), and for neutral detergent fibre (NDF) and acid detergent fibre (ADF) by the procedures of Goering and Van Soest (1970). Whole blood samples were analysed for haemoglobin (Hb), packed cell volume (PCV), total white blood cells (WBC), and differentials (neutrophiles and lymphocytes) according to the methods described by Coles (1974).

Data management and analysis

Data collected was computed using Microsoft Excel software (Microsoft XP). Statistical analysis was done using the general linear model procedure of Statistical Analysis System (SAS, 1987). The model used was: $Y_{ijk} = \mu + B_j + X_{ijk} + T_k + e_{ijk}$. Where μ = represent a mean; B = Block; X_{ijk} = covariate; T = treatment; e_{ijk} = residual term.

RESULTS

Composition of experimental diets

The chemical composition of the concentrate feeds and hay are shown in Table I. Dry matter contents of the concentrate diets were similar, averaging 96.3%. 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, thus diet with 0% whole cottonseed had the lowest crude fibre content (21.6%) and the diet with 75%whole cottonseed had the highest (43.5%). 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. The hay contained 95.2% dry matter, 10.5% CP, 25.8% CF, 8.6% Ether extract, 56.2% NDF, 38.5% ADF, and 10.8% ash.

Feed intake and weight gain

There was a significant decline ($P<0.05$) in concentrate intake by Friesian x Bunaji calves with increase in the level of whole cottonseed in the diet (Table II). Concentrate intake was significantly higher ($P<0.05$) in calves fed 50% whole cottonseed diet than those fed 75% whole cottonseed diet. Intake values in both groups were significantly lower ($P<0.01$) than in calves fed 0 and 25% whole cottonseed diets. However, the difference in concentrate intake between calves on 0 and 25% whole cottonseed diets was not significantly different ($P>0.05$). Hay intake declined slightly with increase in the level of whole cottonseed in the diets, although the differences were not significant ($P>0.05$).

Body weight gains of calves fed concentrate diet containing 0% whole cottonseed was significantly higher ($P<0.01$) than those of calves fed 25, 50, and 75% whole cottonseed diets (Table II). Mean daily weight gain of calves on 25 and 50% whole cottonseed diets was not significantly different ($P>0.05$). Feed to gain ratio increased significantly ($P<0.01$) as the level of whole cottonseed increased. The difference in feed: gain ratio between 25 and 50% whole cottonseed diets was significant ($P<0.05$). Two of the calves

among the group fed the 75% whole cottonseed diets developed abdominal distension and showed poor growth rate and unthriftness; however, no mortality was recorded.

Nutrient digestibility and nitrogen balance

Nutrient digestibility values are shown in Table III. Dry matter and organic matter digestibilities declined significantly ($P<0.01$) with increase in the level of whole cottonseed in the diet. Dry matter digestibility was similar in animals fed 0 and 25% whole cottonseed diets (63.5 vs. 63.7%, respectively), and was not significantly different ($P>0.05$) in those fed 50 and 75% whole cottonseed diets.

The highest organic matter digestibility (64.5%) was recorded in animals on 0% whole cottonseed diet. Organic matter digestibility in animals fed 50 and 75% whole cottonseed diets was not significantly different ($P>0.05$). Both crude protein and NDF digestibilities increased significantly ($P<0.05$) with increase in the level of whole cottonseed in the diet. However, there was no significant difference ($P>0.05$) in crude protein digestibility in animals fed 25, 50, and 75% whole cottonseed diets.

NDF digestibility was not significantly different ($P>0.05$) in animals fed 25 and 50% whole cottonseed diets. Although there was a slight increase in acid detergent fibre digestibility with increase in the whole cottonseed in the diet, the differences were not significant ($P>0.05$). Ether extract digestibility increased significantly ($P<0.01$) with increase in the level of whole cottonseed in the diets.

Dietary nitrogen intake by the calves declined significantly ($P<0.01$) with the feeding of whole cottonseed, although nitrogen intake was not significantly different ($P>0.05$) in calves fed 25, 50 and 75% whole cottonseed diets. There were significant ($P<0.01$) increases in both faecal and urinary nitrogen output with increase in whole cottonseed in the diet. There was no significant difference ($P>0.05$) in faecal nitrogen output of calves fed 0, 25, and 50% whole cottonseed diets, and in urinary nitrogen output in calves fed 25, 50 and 75% whole cottonseed diets. Nitrogen balance declined significantly ($P<0.01$) as the level of whole cottonseed increased in the diet. Amount of nitrogen retained declined significantly ($P<0.01$) with increase in the level of whole cottonseed. Nitrogen retention was not significantly different ($P>0.05$) in calves fed 25 and 50% whole cottonseed diets.

Blood parameters

Changes in haematological parameters in Friesian x Bunaji calves are shown in Table IV. The results showed a significant ($P<0.05$) decline in packed cell volume of calves fed 50 and 75% whole cottonseed diets compared to those fed 0 and 25% whole cottonseed diets. Also, there was a slight decline in haemoglobin concentrations, although the difference was not significant ($P>0.05$). There were slight increases in total white blood cells and differentials (neutrophiles, and lymphocytes) in calves with increase in whole cottonseed, but the difference in the values were not significant ($P>0.05$).

TABLE 1:Composition of experimental diets (%)

Ingredient	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Whole cottonseed	0	25	50	75
Cottonseed cake	48.0	0	0	0
Wheat bran	13.7	49.3	27.3	11.6
Maize	35.3	22.7	19.7	10.4
Bone meal	2	2	2	2
Table salt	1	1	1	1
Dry Matter	96.0	96.1	96.2	96.7
Crude protein	16.0	15.4	16.3	17.8
Crude fibre	21.6	28.2	33.4	43.5
Ether extract	11.0	17.9	24.0	25.6
Neutral detergent fibre	23.4	34.5	34.6	34.8
Acid detergent fibre	24.1	28.7	31.6	41.4
Ash	11.0	10.5	6.8	6.5
ME (Kcal/kg)	3063.7	2831.5	3397.5	3603.1
Estimated Gossypol*	0.033	0.289	0.577	0.866

Metabolizable Energy, Estimated gossypol (kg/kg); *Estimated from Fetuga and Ikurior, 1982)

TABLE 2:Feed intake and weight gain in Friesian x Bunaji calves fed varying levels of whole cottonseed

	Inclusion levels of whole cottonseed (%)					
Parameters	**0**	**25**	**50**	**75**	**SEM**	**LOS**
Concentrate intake (kg/day)	2.20^{a}	2.12^{a}	1.89^{b}	1.55^{b}	0.08	**
Hay intake (kg/day)	3.49	3.44	3.40	3.39	0.10	ns
Total feed intake (kg)	796.6^{a}	778.4^{b}	740.60^{c}	691.60^{d}	3.42	**
Average daily feed intake (kg/head/day)	5.69^{a}	5.56^{a}	5.29^{b}	4.94^{c}	0.17	*
Total weight gain (kg)	122.3^{a}	63.5^{b}	48.4^{c}	29.6^{d}	0.2	**
ADG (kg/day)	0.873^{a}	0.454^{b}	0.346^{b}	0.210^{c}	0.072	**
Feed: gain ratio	6.52^{d}	12.24^{c}	15.31^{b}	23.38^{a}	0.18	**

Means within the same row with different superscripts are significantly different. LOS = Level of significance: ** = P<0.01, * = P<0.05, ns = not significant

TABLE 3: Nutrient digestibility and nitrogen balance by Friesian x Bunaji calves fed varying levels of whole cottonseed

	Inclusion levels of whole cottonseed (%)					
Parameters	**0**	**25**	**50**	**75**	**SEM**	**LOS**
Apparent digestibility						
Dry Matter	63.4[a]	63.7[a]	61.2[b]	60.2[b]	0.8	**
Organic matter	64.5[a]	61.5[b]	57.7[c]	56.2[c]	3.2	**
Crude Protein	30.5[b]	31.5[ab]	32.2[a]	33.4[a]	1.2	*
NDF	69.7[c]	72.1[b]	73.8[b]	75.7[a]	1.8	*
ADF	30.4	31.5	32.8	33.4	2.3	ns
Ether Extract	84.2[d]	88.1[c]	90.4[b]	92.6[a]	1.3	**
Nitrogen balance						
Nitrogen intake	118.0[a]	117.3[ab]	115.6[b]	113.9[b]	1.7	*
Nitrogen output						
Faecal	21. 6[c]	23.6[b]	24.1[b]	27.5[a]	1.5	**
Urine	21.3[b]	28.0[a]	28.7[a]	29.5[a]	1.8	**
Total	42.9[d]	50.6[c]	52.8[b]	57.1[a]	1.1	**
Nitrogen retained (g/day)	75.1[a]	66.7[b]	62.8[c]	56.8[d]	1.4	**
Nitrogen retained (%)	63.3[a]	58.2[b]	57.0[b]	50.8[c]	3.4	**

Means within the same row with different superscripts are significantly different. LOS = Level of significance: ** = P<0.01, * = P<0.05, ns = not significant

TABLE 4:Haematological changes in Friesian x Bunaji calves fed varying levels of whole cottonseed

	Inclusion levels of whole cottonseed (%)					
Parameters	0	25	50	75	SEM	LOS
Packed cell volume (g/100 ml)	30.4[a]	30.2[a]	28.4[b]	27.2[b]	1.2	*
Haemoglobin (g/100 ml)	10.1	9.9	9.8	9.8	0.5	ns
White blood cells ($x10^6$)	11.0	11.3	11.8	12.0	0.8	ns
Neutrophils (%)	28.0	28.2	29.4	30.2	3.6	ns
Lymphocytes (%)	78.1	77.8	78.0	78.8	3.8	ns

Means within the same row with different superscripts are significantly different. LOS = Level of significance: * = P<0.05, ns = not significant

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 (Coppock et al., 1987; 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 this often affects the fibre content.

The general decline in feed intake with increase in the level of whole cottonseed observed in this study agrees with the reports of Coppock et al. (1987) and Lanham et al. (1992). These authors reported a sharp decline in dry matter intake as whole cottonseed levels increased from 35 to 55% of the diet. Coppock et al. (1985) had earlier reported a significant linear depression (10%) in dry matter intake per body weight and per unit metabolic body weight as whole cottonseed increased from 0 to 30% of the diet. However, Anderson et al. (1982), and Harvatine et al. (2002) reported significant increases in dry matter intake with increase in the proportion of dietary whole cottonseed. The non-significant difference in concentrate intake by calves fed 0 and 25% whole cottonseed diets agrees with Coppock et al. (1987) who reported that dry matter intake remained unchanged when whole cottonseed was included at up to 25% of the diet. The slight decline in hay intake by calves despite the depression in concentrate intake at high whole cottonseed levels could have been caused by the entrapment of whole cottonseed in the ruminal mat, which retarded its passage, and increased gut fill (Clark and Armentano, 1993; Varga et al., 1998).

The significant decline in average daily weight gain of calves with increase in the levels of whole cottonseed in the diets agrees with the reports of Coppock et al. (1985, 1987), Morgan (1992) and Rogers et al. (2002). The result, however, is at variance with the reports of Anderson et al. (1982), which showed that calves that consumed whole cottonseed diets were heavier than those on non-whole cottonseed diets. The better performance of calves fed the diet with 25% whole cottonseed is also at variance with the report of Poore (1994) who suggested an upper limit of 15% of the total diet for feeding whole cottonseed to growing cattle. The low weight gain of calves on the 75% whole cottonseed diet could be due to insufficient nutrient intake occasioned by the high amount of rejected feed, which was mainly whole cottonseed. The increase in the feed: gain ratio with increase in whole cottonseed in the diets implies a decrease in feed efficiency. This shows that calves fed the 25, 50 and 75% whole cottonseed diets required more feed per unit of body weight gain than those fed the 0% whole cottonseed diet. The abdominal distension, poor growth and unthriftness observed in 2 of the calves fed the 75% whole cottonseed diet are possible signs of gossypol toxicity (Lindsey et al., 1980; Smalley and Bicknell, 1982).

The dry matter digestibility values recorded in this study were similar to those of Anderson et al. (1982) and Coppock et al. (1985), but lower than was reported by Zinn and Plascencia (1993). The decrease in dry matter digestibility in animals on 50 and 75% whole cottonseed diets compared to those on 0 and 25% whole cottonseed diets agrees with the report of Anderson et al. (1982), Coppock et al. (1985), and Zinn and Plascencia (1993). Further more the observed decline in organic matter digestibility in diets with 50 and 75% compared to those with 0 and 25% is in line with the reports of Zinn and Plascencia (1993). This could be attributed to increase in the fibre (lignin) content of the diets as the level of whole cottonseed increased.

The increase in the digestibility of crude protein, neutral detergent fibre, and ether extracts is also consistent with what has been reported (Zinn and Plascencia, 1993; Sullivan et al., 1993 and Zinn, 1995). This

could be attributed to increase in availability of protein in the rumen with increase in the level of whole cottonseed in the diet for microbial growth and activities. However, the increase in ether extract digestibility with increase in the level of whole cottonseed seems to contradict the reported negative influence of high oil content of whole cottonseed on fibre digestion (DePeters and Cant, 1992; Jenkins, 1993). The absence of whole cottonseed in the faeces suggests that it was extensively degraded in the rumen. This is also consistent with the reports of Coppock et al. (1985b), and Zinn and Plascencia (1993), who found very little (between 0.45 and 0.75%) whole cottonseed in the faeces. The decline in dietary nitrogen intake coupled with the increase in faecal and urinary nitrogen output contributed to the low nitrogen retention as whole cottonseed increased in the diets. Olayiwole et al. (1975), Marion et al. (1976), and Mossi and Butterworth (1985) reported similar decline in nitrogen retention at high level of whole cottonseed in the diets. Despite the low nitrogen retention, all the animals remained in positive nitrogen balance.

The decrease in packed cell volume in Friesian x Bunaji calves fed 50 and 75% whole cottonseed diets agrees with the observations of Smalley and Bicknell (1982), and Morgan (1993). However, the rate of decline was not as sharp as was reported by these authors. The non-significant ($P>0.05$) differences in haemoglobin, total white blood cells and cell differential (neutrophiles and lymphocytes) counts across treatments contradicts the reported increases with whole cottonseed feeding (Coppo et al, 1994), but agrees with the reports of Collin-Negrete et al. (1996). It is possible that the depressed feed intake observed with increase in the level of whole cottonseed in this study meant the amount of gossypol ingested by the calves were below toxicity levels, hence the non-significant differences in blood parameters.

CONCLUSION

From the results of this study it could be concluded that both feed intake and weight gain by Friesian x Bunaji calves were depressed at high levels of whole cottonseed levels. Dry and organic matter digestibility declined with increase in the level of whole cottonseed in the diet. Crude protein, acid detergent fibre, neutral detergent fibre, and ether extract digestibility increased with increase in the level of whole cottonseed. The result also shows that although there were no significant changes in the values of blood parameters it is uneconomical to supplement calves in this age group with diets containing more than 25% whole cottonseed.

ACKNOWLEDGEMENT

The authors are grateful to the Director, National Animal Production Research Institutes, Ahmadu Bello University Zaria for funding of the study, and staff of the Dairy Research Programme, NAPRI, ABU, Zaria for their dedication to duty, which led to the success of the study.

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