Effect of Processing Cotton Straw Based Complete Diet with Expander-extruder on Performance of Crossbred Calves

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ABSTRACT : A growth trial of 180 days was conducted on 18 crossbred calves (6-9 months, 73.48±6.52 kg) by randomly allotting to two complete diets and a conventional diet (6 in each group). The complete diets were formulated containing 40 per cent cotton straw, one processed in mash form and other subjected to expander-extruder pelletization (EEP). These two complete diets were compared with conventional system of feeding under which concentrate mixture and cotton straw were fed separately in a 60:40 ratio. The calves on EEP complete diet consumed more ($p<0.01$) DM in comparison to other two groups. The DMI per 100 kg body weight was similar among all the diets. The ADG was significantly ($p<0.01$) higher in calves fed EEP complete diets (815.4 g) followed by mash (627.0 g) in comparison to conventional diet (464.9 g). The DM intake per kg metabolic body weight was higher ($p<0.01$) on complete diet than conventional diet. The intakes of DCP ($p<0.05$), TDN ($p<0.01$), and ME ($p<0.01$) per kg metabolic body weight were significantly higher on EEP complete diet in comparison to mash and conventional diet. The water intake per kg DM intake was comparable among all the diets. The efficiency of DM utilisation was higher p (<0.05) on EEP complete diet (5.84) in comparison to conventional diet (7.41), whereas on mash diet it was intermediate (6.68). The efficiency of DCP utilization was similar in mash and EEP complete diet fed groups, which was higher ($p<0.05$) than that of the conventional diet. Expander-extrusion though increased the cost of production it reduced the cost of feed per unit live weight gain by 12.28% in comparison to its mash form and by 16.76% when concentrate and cotton straw were fed separately. The results indicated that blending of cotton straw along with concentrates in a complete diet increased the palatability of the straw in comparison to conventional system and expander extruder processing of cotton straw based complete diet gave better growth performance and may form an economic ration for growing crossbred calves. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 11 : 1572-1576)***

Key Words : Cotton Straw, Expander-extrusion, Growth, Calves

INTRODUCTION

Chronic feed deficit represent a major constraint to animal production in many of the developing countries due to population increase and consequent allocation of available land for cereal production thereby reducing the availability of cultivated land for animal fodder production. This situation demands the use of available crop residues and unconventional feed resources in the livestock rations. One in this direction is the use of cotton straw (CS), left in the fields after the last picking of the cotton. In India, it is available to the tune of 14.35 million tones (Kairon et al., 2000), which is presently used as fuel or organic manure. The CS is low in protein, energy and has poor digestibility mostly due to highly lignified cell walls. Efforts have to be made to make it a quality roughage for ruminants. Various measures like grinding (Reddy et al., 1992), pelleting (Reddy and Reddy, 1985; Reddy, 1990), treating with chemicals like NH_3 (Reddy and Reddy, 1986), ozone and sodium hydroxide (Ben-Ghedalia et al., 1982) were tried to improve the nutritive value of CS. The chemical treatments were though effective in improving the palatability and nutritive value of the straw, the process was laborious and uneconomical. The use of expander extruder processing, a deviation from traditional pelleting is in wide use in processing of poultry, swine and aqua feeds. Thus, in the present study, an attempt has been made to study the effect of incorporating CS as sole roughage in complete diets of calves and also to evaluate the effect of processing such complete diets with expander-extruder.

MATERIALS AND METHODS

Animals

Eighteen, 6-9 months old crossbred male calves (Jersey ×Tharparker) of uniform body weight (73.48±6.52 kg) were allocated to 3 groups of 6 animals each in a completely randomized design. Animals were vaccinated against foot and mouth disease and Theileriasis as per the schedule. The calves were dewormed with albendazole suspension before the start of the experiment.

Processing of experimental rations

The CS procured from nearby cotton fields was ground with 8 mm sieve. The ground CS was used as a sole roughage source in all the 3 treatment diets. The diets were 1) complete diet containing 40% CS, processed in mash

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Table 1. Dietary ingredient and chemical composition of experimental diets and cotton straw

Attribute	Cotton straw	Concentrate mixture	Complete diet	
			Mash	EEP
Ingredient kg (% in air dry feed)				
Cotton straw (ground)		-	40.0	40.0
Maize		30.0	23.0	23.0
Groundnut cake		17.0	10.0	10.0
Cottonseed cake		11.5	5.0	5.0
Deoiled rice bran		30.0	9.0	9.0
Molasses		7.0	10.5	10.5
Urea		1.5	1.0	1.0
Common salt		1.0	0.5	0.5
Mineral mixture[a]		2.0	1.0	1.0
Vitamin AD_3 (gm)[b]		20	10	10
Analysed chemical composition (% in DM)				
Dry matter	97.68	98.19	98.35	97.57
Organic matter	95.59	88.76	92.41	92.46
Crude protein	6.63	18.15	12.70	12.69
Ether extract	2.99	3.32	2.43	2.44
Neutral detergent fibre	76.32	45.07	58.77	56.03
Acid detergent fibre	67.47	28.03	41.26	39.60
Cellulose	18.57	8.03	10.30	11.34
Lignin	48.50	17.29	30.05	29.35
Calcium	0.90	0.95	1.02	1.04
Phosphorus	0.67	1.01	1.02	0.87

[a] Each 100 g of mineral mixture (Mastimin) contained, Ca 24 g; P 9 g; Mn 200 mg; I 50 mg; Fe 600 mg; Cu 500 mg; Co 20 mg; Zn 200 mg; Se 0.05 ppm and Mb 0.00125 ppm with fortified lipo-polysaccharides. [b] Each g of vitamin AD_3 (Rovimix) contained, Vitamin A 50,000 IU and Vitamin D_3 5,000 IU.

from 2) complete diet containing 40% CS. processed with expander-extruder pelletizer (EEP) and 3) conventional diet containing concentrate mixture plus ground CS fed separately. The ingredient composition of the experimental diets is given in Table 1.

Processing with expander-extruder pelletizer

The complete feed prepared in mash form was conditioned with steam in the first chamber (inlet) of the expander-extruder (Niharika equipments Pvt. Ltd., India). The feed containing 17-18% moisture was then passed through a single continuous barrel containing a shaft interrupted with screws. The feed material gets moved and pushed forward through a constricted passage resulting in increased temperature and pressure, causing gelatinization and agglomeration of the feed. At the last section of the barrel, the temperature of 85-90°C is achieved to which the feed is subjected for about 30 seconds. The gelatinized expander extruder feed comes out through a die plate having 16 mm sized die holes at the other end of the barrel. The pellets of 16mm diameter with final moisture of 14-15% were obtained. The hot pellets were then cooled and stored in gunny bags.

Feeding regime and housing management

The calves of all the groups were fed as per the NRC (1989). The calves were daily fed with weighed quantities of respective diets twice a day at 9:00 and 14:00 h throughout 180 days of experimental feeding. The animals under conventional diet received concentrate mixture in morning and ground cotton straw *ad libitium* in evening. The roughage: concentrate ratio of 40:60 was maintained under conventional feeding by adjusting the concentrate intake based on the daily feed intakes of the preceding fortnight. The other two groups were fed complete diet in mash and expander-extruder pellet *ad libitium* twice daily. The calves were housed individually in a well ventilated, cement-floored shed, each provided with separate feeding and watering facilities. All calves were raised under hygienic and uniform managerial conditions. Clean, fresh and wholesome water was made available to all the animal *ad libitium* throughout the trial.

Body weight and feed consumption

At the beginning of the experiment, animals were weighed individually for two consecutive days at morning before feeding and watering and thereafter every fortnight for two consecutive days to observe the body weight changes.

Each calf was daily offered weighed quantities of respective rations twice a day. The residues were collected and weighed next day before offering the feed to find out daily feed intake. The efficiency of feed and nutrient utilization was calculated as intake per unit gain. The samples of feeds offered and residues collected every fortnight were analysed for dry matter (DM) to arrive at

Table 2. Body weight changes in crossbred calves fed cotton straw based diets

Attributes	Conventional	Complete diet		SEM
		Mash	EEP	
Initial body weight (kg)	73.54	73.50	73.40	6.520
Final body weight (kg)	157.3[a]	186.4[b]	220.1[c]	9.23
Total gain (kg)	83.68[a]	112.87[b]	146.74[c]	5.156
Average daily gain (g)	464.9[a]	627.0[b]	815.4[c]	28.63

Means with different superscripts in a row differ significantly: $p<0.01$.

Table 3. Dry matter and nutrient intake by crossbred calves fed cotton straw based diets

Attributes	Conventional	Complete diet		SEM
		Mash	EEP	
DM intake (kg)	3.38[a]	4.13[b]	4.76[c]	0.139**
DM intake/100 kg body weight (kg)	2.98	3.20	3.25	0.124
Intake/kg $W^{0.75}$				
DM (g)	97.00[a]	107.67[b]	113.20[b]	3.152**
DCP (g)	8.17[a]	8.33[a]	9.67[b]	0.387*
TDN (g)	55.17[a]	60.17[a]	71.00[b]	2.871**
DE (kcal)	242.2[a]	265.7[a]	313.3[b]	12.92**
ME (kcal)	198.5[a]	218.0[a]	256.8[b]	10.54**
Concentrate: roughage ratio	57:43	60:40	60:40	-
Water intake/kg DMI (L)	5.03	4.76	4.53	0.178

Means with different superscripts in a row differ significantly: * $p<0.05$; ** $p<0.01$.

DM intake (DMI).

Analytical procedure

The feed samples were analysed for proximate constituents and phosphorus as per the procedure of AOAC (1997). The fibre fractions and calcium were determined as per the procedure of Van Soest et al. (1991) and Talapatra et al. (1940), respectively. The gross energy was estimated as per the procedure described in the manual of Gallemkemp Automatic Ballistic Bomb Calorimeter. The values for digestibility of the nutrients and energy content of the rations to calculate the nutrient intakes and its efficiency of utilization were taken from the values reported by Kirubanath (2001).

Cost of feeding and cost economics

The feed cost of each ration was calculated using the ingredient and processing cost prevailing at the time of experimentation. The processing cost was calculated by estimating the cost of power, labour, depreciation and insurance of the machineries and building. The total feed cost was obtained by summing the cost of processing plus cost of feed consumed throughout the feeding period (180 d). The feed cost per kg live weight gain was calculated by dividing the cost of feed consumed over 180 d by total live weight gain achieved in the same period.

Statistical analysis

The data was subjected to analysis of variance (Snedecor and Cochran, 1968) and the means were tested for significance by Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

The nutrient composition of the CS, concentrate and complete diets (mash and EEP) is presented in Table 1. The CS contained 6.63% CP, 2.99% ether extract (EE) and 76.32% NDF on DM basis. The CP content of CS was in concurrent with the values (6.66 and 6.59%) reported by Malsur et al. (1998) and Ramachandra Rao et al. (1994), respectively. On the other hand, lower CP (4.2%), EE (1.7%) and NDF (60.8%) values were reported by Reddy and Reddy (1992) for ground cotton straw compared to those reported in the present study. Expander-extruder pelleting of complete diet did not affect the chemical composition of the diet (Table 1).

A linear increase in live body weight was observed in calves on all the diets throughout 180 days of experimental feeding. Dietary variations did not significantly influence the fortnightly body weight changes of calves during first seven fortnights. The body weight of calves fed EEP diet was higher ($p<0.01$) than that of calves on conventional diet from 8-12th fortnights. While, the body weight of calves consuming mash diet was comparable with that of conventional group and EEP diet fed calves during these fortnights. The calves grew with an average daily gain of 815.4 g which was significantly higher ($p<0.01$) than gains observed in calves fed complete diet in mash form (627.0 g) (Table 2). The average daily gain was lowest ($p<0.01$) in calves fed conventional diet (464.9 g). The higher growth rate observed in EEP fed calves might be a result of higher nitrogen and mineral retentions and increased digestibilities of DM, fat and nitrogen free extract (Kirubanath, 2001). Similar beneficial effects of processing, on weight gains was observed due to pelleting of cotton straw containing diets or incorporating CS after ozone treatment in complete diets of calves (Reddy and Reddy, 1985) and lambs (Solomon et al., 1992), respectively.

Blending of cotton straw along with concentrate mixture increased the palatability as evident by higher ($p<0.01$) DM

Table 4. Efficiency of nutrient utilization in crossbred calves fed cotton straw based diets

Nutrient	Conventional	Complete diet		SEM
		Mash	EEP	
Dry matter	7.41 [b]	6.68 [ab]	5.84 [a]	0.362
Crude protein	1.06	0.93	0.88	0.055
Digestible crude protein	0.62 [b]	0.50 [a]	0.50 [a]	0.029
Total digestible nutrients	4.18	3.72	3.66	0.224

Means with different superscripts in a row differ significantly: $p<0.05$.

Table 5. Cost economics of cotton straw based diets fed to crossbred calves

Attribute	Conventional	Complete diet		SEM
		Mash	EEP	
Feed consumed (kg)	666.3 [a]	834.1 [b]	952.0 [c]	31.687
Weight gain (kg)	83.68 [a]	112.87 [b]	146.74 [c]	5.160
Cost of feed consumed ($)	63.26 [a]	81.18 [b]	93.48 [c]	2.758
Cost of feeding per kg live weight gain ($)	0.77	0.73	0.64	0.034

Means with different superscripts in a row differ significantly: $p<0.01$. 1 US $=Rs. 48.80.

intake in comparison to conventional diet. Expander extrusion of complete diet further increased ($p<0.01$) the palatability (Table 3). The higher ($p<0.01$) DMI by EEP group calves throughout the entire feeding trial in comparison to those on conventional diet might be due to higher nutrient requirements for increased body weight gain. The daily DMI by calves fed on complete diet either in mash or EEP form during first 4 fortnights, 7 and 9th fortnight did not differ but the intakes in remaining fortnights were higher when the complete diet was EEP. The DM intake was higher when fed mash diet in comparison to conventional diet from 1-9th fortnight but these differences disappeared from 10th fortnight onwards. The concentrate: roughage ratio in complete diets was 60:40, whereas, in the conventional ration it was 57:43, indicating that the ratio was similar to that of complete diets. The lowest ($p<0.01$) feed intake by conventional diet fed calves may be attributed to the poor palatability of cotton straw when fed separately. The water intake per kg DM intake was comparable among all the diets.

The lower ($p<0.01$) intake of DM and other nutrients per unit metabolic body weight in conventional diet fed calves was consequently due to the lower body weight gain as compared to complete diets (Table 3). The DMI per 100 kg body weight was similar among all the diets and ranged between 2.98 and 3.25 kg. These were comparable to the values recommended by Kearl (1982) which ranged between 2.90 to 3.10 kg. Pelleting of ground CS improved ($p<0.05$) the DMI in goats (Reddy et al., 1992). The higher DMI by EEP diet fed calves resulted in higher ($p<0.01$) daily intakes of TDN, DE, ME and DCP ($p<0.05$) in comparison to other two groups (Table 3). The DM, protein and energy intakes by all groups of calves were higher than the values recommended by NRC (1989) as well as Kearl (1982) for similar body weight and daily gain. Such higher intakes of these nutrients was also observed by Reddy and Reddy (1999a) in calves and by Reddy and Reddy (2000) in buffaloes when fed extruded complete diets containing either sorghum straw (28.50%) or maize cobs (40%), respectively.

The calves on either conventional or complete diets utilized CP and TDN with similar efficiency (Table 4). The DM required to produce a unit weight gain was lower ($p<0.05$) in EEP fed calves when the complete feed was expander-extruder processed. These results corroborated with the findings of Reddy and Reddy (1985) who reported that pelleting of 45% CS based ration decreased ($p<0.01$) the DM required per kg live weight gain in calves. Similarly, Reddy and Reddy (1999b) reported significantly ($p<0.05$) higher DM efficiency in calves fed with extruded complete diet containing maize cobs (40%) when compared to conventional feeding. The efficiency of DCP utilisation was significantly ($p<0.05$) higher in complete diets in comparison to those fed concentrate and CS, separately.

Inclusion of 40% CS in complete feeds increased the power consumption due to the low bulk density and fibre resistance to particle size reduction in the process of grinding CS. Expander extrusion required additional power consumption for steam production and the cost of processing of EEP diet increased by 19.02% over the mash diet. The cost (inclusive of ingredients and processing cost) of concentrate mixture, cotton straw, complete diet in mash and expander extruder processed form was 13.75, 3.91, 9.73 and 9.83$ per quintal, respectively. The feed consumed by the calves was highest ($p<0.01$) in EEP diet fed groups followed by mash and then by conventional group (Table 5). Feeding of expander-extruded pelleted diet reduced the cost of feed per unit live weight gain by 12.28% and 16.76% in comparison to mash and conventional diet feeding, respectively due to increased efficiency of DM and nutrient utilization (Table 4).

CONCLUSION

Cotton straw may serve as a sole roughage source in complete diets of growing calves. Processing of cotton straw based diet with expander-extruder improved the palatability and resulted in higher daily gains and feed efficiency. This processing technology proved more economical than its mash form or feeding cotton straw and concentrate separately under conventional system of feeding.

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