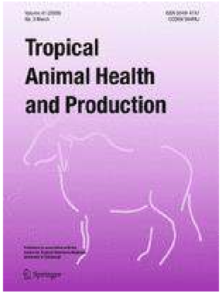

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Growth Performance and Carcass Characteristics of Growing Ram Lambs Fed Sweet Sorghum Bagasse Based Complete Rations Varying in Roughage to Concentrate Ratios

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ABSTRACT

Different roughage to concentrate ratios of sweet sorghum bagasse (SSB), a by-product of bio fuel industry, based complete diets were assessed. Twenty four growing Nellore X Deccani ram lambs aged about 3 months (average body wt. 10.62±0.25 kg) were randomly allotted to four complete rations (CR) varying in roughage to concentrate ratios viz. 60:40 (CR-I), 50:50 (CR-II), 40:60 (CR-III) and 30: 70(CR-IV) for a period of 180 days. The feed intake was comparable among the lambs fed different experimental complete diets. Average daily weight gain (g) was 77.31±4.90, 81.76±5.16, 85.83±2.83 and 86.30±3.25 and feed conversion ratio (kg feed/kg gain) averaged 11.42±0.68, 10.57±0.64, 10.17±0.37 and 9.96±0.38 in ram lambs fed CR-I, CR-II, CR-III and CR-IV rations, respectively. Statistically, differences in daily weight gain and feed conversion ratio among the lambs fed four experimental rations were not significant ($P>0.05$). The cost per kg gain was significantly ($P<0.01$) higher in ram lambs fed CR-IV and CR-III rations compared to

CR-I ration and it was comparable between CR-I and CR-II rations. Dressing percentage averaged 44.90±0.15, 42.57±0.72, 43.67±0.16 and 44.42±0.76 for the respective diets. No significant difference and trend was observed in pre slaughter weight, empty body weight, carcass weights, dressing percentage, wholesale cuts and edible and non-edible portions of experimental animals. Similarly, no significant variation could be seen in bone and meat yield (%) and their ratios in various wholesale cuts among the dietary treatments. The roughage to concentrate ratio did not affect the chemical composition of meat, however, the fat content of meat was linearly increased with increase in the proportion of concentrate in the diets. The results of the experiment indicated that, SSB can be included at 60% level in the complete diet for economical mutton production from growing Nellore X Deccani ram lambs.

Key words: Sweet sorghum bagasse · Roughage to concentrate ratio · Growth performance · Carcass traits · Lambs

Introduction

In heavily cultivated countries like India, the feeding system of ruminants is agricultural by-products dependent rather than grassland dependent. The efficiency of a ruminant feeding system in these countries, therefore, relies on how efficiently agricultural by-products are used. In the traditional extensive practice, sheep are fed crop stalks supplemented with a little concentrate. Though this feeding system may minimize daily feed cost, it is not a reasonable system to optimize the feed efficiency of agricultural by-products and the profit of sheep production. As a result of the importance of sheep production in India, the production system becoming more intensive in recent years, much effort on agricultural by-products processing techniques has been made to improve their feed efficiency. Sweet sorghum bagasse (SSB) is one among the agro industrial by- products available in recent days. Sweet sorghum (*Sorghum bicolor* (L) Moench) a triple purpose crop, is well adapted to the Semi-Arid Tropics and is one of the most efficient dry land crops to convert atmospheric CO_2 into sugar. The crop is therefore gaining rapid importance as an alternative feedstock for bio-ethanol production. Despite the increasing industrial usage, farmers still consider sweet sorghum a multipurpose crop from which they also expect grain for human consumption and fodder from the stover. While the demand for sweet sorghum for ethanol production provides important income for dry land farmers, it also diverts biomass away from livestock, thus adding to the feed scarcity problem. Using the bagasse remaining after juice extraction (for ethanol) and the stripped leaves could compensate for fodder loss and provide an additional source of income. Thus, fodder quality of feed made of leaf strippings and bagasse is similar to premium stover from grain sorghum (Blummel *et al*., 2009).

However, the stalk residue after extraction of juice is generally considered to be low in protein, energy and have poor digestibility mostly due to highly lignified cell walls. But, the palatability and utilization of unconventional feedstuffs and agro-industrial by- products can be improved by incorporating into complete diets (Reddy and Reddy, 1999). The incorporation of concentrates into ruminant diets is intended to increase dietary energy, proteins, minerals, and vitamins and to optimize the efficiency of feed utilization. The degree to which concentrates affect fiber digestion may depend on the nature and proportion of the concentrate as well as the quality of the roughage (Matejovsky and Sanson, 1995). Therefore, there may be an optimal concentrate supplementation level for a given kind of roughage, which allows the animal to use the nutrients in the roughage most efficiently.

Further, the slaughter traits, in turn are modulated by heredity, feeding regimen and prevailing rearing environment. Carcass evaluation is essential for growth studies to determine relative efficiency of finisher lambs in converting feed to animal tissue. The aim of the present study was to establish the suitable roughage to concentrate ratio of growing ram lambs fed sweet sorghum bagasse based diets by studying the influence of concentrate supplementation level on the growth performance and carcass traits.

Materials and methods

Site of study

The experiment was carried out at the College of Veterinary Science, S V Veterinary University, Rajendranagar, Hyderabad (17^0 12′ N, 78^0 18′ E, 545 m above sea level) in India. The ambient temperature and relative humidity values during the period of study were in the range of 28- 42^0 C and 28-32%, respectively.

Experimental diets

Experimental rations containing complete diets were processed into mash with SSB to concentrate ratio of 60:40 (CR-I), 50:50 (CR-II), 40:60 (CR-III) and 30:70 (CR-IV) and offered to the lambs during the experimental period. The ingredient composition of experimental rations is presented in Table 1. Sweet sorghum bagasse with stripped leaves is used as a roughage source in the experimental rations. A concentrate mixture (20% CP; 10.6 MJ ME) was formulated with locally available feed ingredients such as maize grain, groundnut cake, sunflower cake, deoiled rice bran, molasses, urea, mineral mixture and salt and included at 40 (CR-I), 50 (CR-II), 60 (CR-III) and 70% (CR-IV) level in the experimental rations.

Experimental animals and rearing

Twenty four growing Nellore x Deccani ram lambs (average body wt. 10.62±0.25 kg) aged about 3 months were randomly distributed into four groups of six animals each in a Completely Randomized Design (CRD) for conducting a growth trial for a period of 180 days. All the animals were kept under hygienic conditions in well ventilated pens (4m x 3m). All the lambs were dewormed and vaccinated against Pestdes Petits Ruminants (PPR) before the initiation of the experiment. Respective rations were offered to the animals twice daily at 9.00 h and 15.00 h. Animals were offered weighed quantities of respective complete rations *ad libitum* throughout the experimental period. Residues, if any were weighed on the next morning. Thus, the exact quantity of feed consumed daily by the experimental animals was recorded throughout the experimental period.

Live weight recording

The experimental animals were weighed fortnightly using an electronic digital balance after 16 h feed deprivation. Weights were recorded on two consecutive days and the mean was taken to represent the body weight. Average daily gain (ADG) for individual lambs was calculated using sum of average daily gains of experiment period divided by experiment days. Feed conversion ratio (FCR) for each lamb was calculated as a ratio of daily feed intake to ADG. Feed cost per kg gain was calculated as a ratio of cost of total feed consumed to total weight gain.

Chemical analysis

Feed and meat samples were analysed for nitrogen using 'Terbotherm' and 'Vapodest' (Gerhard, Germany) analysers based on the micro-Kjeldhal method (AOAC, 1997; procedure no. 4.2.02). Dry matter, total ash and ether extract were determined according to procedures (nos. 4.1.03, 4.1.10 and 4.5.01, respectively) described by AOAC (1997). The neutral detergent fibre (NDF) was estimated using sodium sulfite and acid detergent fibre (ADF) described by Van Soest et al. (1991). The NDF and ADF fractions include residual ash. Calcium was estimated as per the method described by Talapatra et al. (1940). Phosphorus was determined colorimetrically as per the method of Ward and Johnston (1962).

Carcass studies

All the lambs were slaughtered after completion of the growth trial and measured the meat characteristics

The lambs were slaughtered by exsanguination using conventional humane procedures after 16 h feed deprivation. The live weights before slaughter were recorded. After complete bleeding, the bodies were skinned and external organs such as head, feet and skin were weighed. Stripping, legging, dressing and evisceration were performed by adopting the standard procedures described by Gerrand (1964).The weight of hot carcasses and organs were recorded. The carcasses were then divided into 5 cuts - leg, loin, rack, shoulder and neck and fore shank and brisket as suggested by the National Livestock and Meat Board of United States of America (Brandly et al., 1968) and the weights of different wholesale cuts were recorded separately. Empty body weight (EBW) was recorded after deducting gut fill from preslaughter weight. The weights of liver, heart, kidneys, testes, spleen, pluck (lungs with trachea), blood, full and empty GIT, skin, dressed head and feet were expressed as per cent of preslaughter weight. The dressing percentage was recorded as weight of hot carcass as per cent of preslaughter weight as well as EBW.

The cut wise separated bone, meat and fat of each group were weighed and expressed as percentages of the whole carcass.

Statistical analysis

Statistical analysis of the data was carried out according to the procedures suggested by Snedecor and Cochran (1994). Least-square Analysis of variance was used to test the significance of various treatments and the difference between treatment means was tested for significance by Duncan's new multiple range and F Test (Duncan, 1955).

Results

Growth study

The chemical composition of complete rations is presented in Table 1. The crude protein content of rations was ranged from 10.21 to 14.37 per cent, respectively. There was an increase in the crude protein content of the rations as the concentrate proportion increased from 40 to 70 per cent, respectively. However, an increase in the proportion of SSB from 30 to 60 per cent in complete ration increased NDF and ADF content and decreased calcium and phosphorus contents due to higher/ lower proportion of concentrate.

The average daily gain (ADG) of lambs (g/d) on experimental diets was comparable as it did not differ significantly due to dietary variations and ranged between 77.31±4.90 to 86.30±3.25 (Table 2). The growth rates of lambs under various feeding regimes were though comparable, the ADG in lambs fed 50, 60, 70 per cent concentrate (CR-II, CR-III and CR-IV) have shown 5.76, 11.02, 11.63 per cent increase compared to CR-I (40% concentrate) diet. On an average 3.75 per cent increase in the weight gain and ADG was observed for every 10 per cent increase in concentrate proportion in the complete rations.

The dietary variations could not affect the dry matter intake (DMI) of lambs significantly (Table 2). Though, an improvement in FCR was observed from CR-I to CR-IV rations, it was not significantly ($P>0.05$) different among the experimental rations. As the proportion of concentrate increased, the FCR was numerically increased. The CR-IV was 12.78 per cent more efficient in feed conversion than the CR-I ration. The growth rate was improved with increase in the proportion of concentrate in the diet and the FCR accordingly improved.

The cost of feed/kg gain (₹) was higher ($P<0.01$) in lambs fed CR-III and CR-IV rations compared to CR-I and CR-II, whereas the cost of feed/kg gain (₹) was comparable between CR-II and CR-I rations (Table 2). The CR-II ration fed lambs have shown 2.26 per cent lowered DMI and 7.44 per cent higher FCR than CR-I ration.

Carcass characteristics and meat quality

The preslaughter weights, empty body weight and carcass weights were not significantly different among the rations (Table 3). Diet had no significant effect on the proportions of the primal cuts (Table 3). No significant difference was observed in edible and non-edible portions of the different treatments.

The data on yield of visceral organs is presented in Table 3. Roughage to concentrate ratio in the complete ration did not affect the yield of pluck, liver, heart, testes, leaf fat, gastro- intestinal tract (GIT), spleen, lungs with trachea as percentage of preslaughter weight.

The bone, meat and fat percentage and bone-meat ratio in whole carcass ranged between 32.38±1.16 and 34.06±0.26, 58.15±1.18 and 60.10±0.69, 7.24±0.45 and 7.80±0.93 and 1.71±0.05 and 1.87±0.08, respectively in lambs fed CR-I, CR-II, CR-III and CR-IV rations (Table 3). No significant variation could be seen in bone and meat yield (%) and their ratios in various wholesale cuts among dietary treatments.

The chemical composition of *Longissimus dorsi* muscle collected from the carcasses of lambs fed different experimental rations is presented in Table 4. The SSB and concentrate ratio in the rations did not affect the chemical composition of meat; however, the fat content of meat was linearly increased with increase in the proportion of concentrate in the diets.

Discussion

Growth performance

The increase in the CP content and decrease in the NDF content as the SSB level increased in the diets were in agreement with Bakshi et al. (2004) with either high roughage or low roughage containing 30:70 or 70:30 concentrate to roughage ratio of wheat straw. The NDF content was decreased proportionally as the forage to concentrate ratio decreased in the diets (Lechartier and Peyraud 2010; Sterk et al. 2011). Dhuria et al. (2008) also reported similar results with bajra straw based diets.

An increase in live weight gain was associated with higher concentrate level (Fimbres et al., 2002). Karim and Rawat (1997) reported that, ADG and feed conversion efficiency were better in lambs maintained on higher level of concentrate in complete feed. Karim (1999) indicated that under mutton production programme with intensive feeding high concentrate complete feed provided better gain and feed conversion efficiency. Carvalho *et al. (*2007) observed that increase in roughage with decrease in concentrate in the diets decreased the live weight gain of the lambs fed diets with 30:70, 40:60, 50:50, 60:40 and 70:30 roughage: concentrate ratios. Santra and Karim (2009) indicated that, the body weight gain and feed conversion efficiency were better in high than low concentrate fed animals. Similar types of observations were also recorded by Jabbar and Anjum (2008), Santra and Karim (2002) in lambs, Haddad (2005) and Singh et al*.* (2009) in kids.

The increased cost/kg feed (₹) of CR-III and CR-IV was due to incorporation of higher proportion of concentrate in the complete diets. Higher cost of feed/kg gain in CR-III and CR-IV diets might have resulted due to insignificant difference observed in the feed intake and total weight gain among the lambs fed various experimental rations and also due to increased proportion of concentrate in the CR-III and CR-IV diets. The results obtained in the present study were in agreement with the findings of Singh et al. (2009) in kids. They reported that, Beetal kids under stall fed conditions on 50:50 roughage to concentrate ratio showed optimal and economic growth performance. Suresha et al. (2009) reported that complete diet with 50:50 concentrate to roughage ratio can be used for economic chevon production. Similar results were reported by Haddad (2005), Ameha Sebsibe et al. (2007) in goats fed diets with 50:50, 65:35, 80:20 concentrate : roughage ratios.

Carcass characteristics and meat quality

Previous studies involving different forage-to-concentrate ratios have demonstrated variable results with respect to carcass traits. In the present experiment, analyzing slaughtering data showed that slaughter weight and empty digestive tract weight were not affected by different dietary concentrate levels.

The results of this study on carcass weight and dressing percentage are similar to those reported by Fimbres et al. (2002). The meat quality attributes were not significantly affected by dietary treatments (Ameha Sebsibe et al., 2007; Dutta et al. 2009; Yuksel et al. 2009; John et al. 2011, Papi et al., 2011). Singh *et al*. (2009) also recorded no difference in dressing percentage with rations containing different roughage to concentrate ratios (50:50, 60:40 and 40:60) consisted of maize, bajra or mixture of maize and bajra along with groundnut haulms in kids. Similar observations were also reported by Anandan *et al*. (2003) and Jain and Bohery (2004) in goats.

The results of carcass composition showed that different levels of dietary concentrate did not affect dissected lean, bone, and inter muscular fat weights. Our results on the weight of the skin, liver, lungs, blood and tesicles coincide with those reported by Fimbres et al. (2002). However, intensive feeding with high concentrate complete feed is usually associated with higher carcass fat content and it is established that carcass fat content exceeding the limits will lower feed conversion efficiency rendering the production system uneconomical (Santra and Karim, 2009). Increasing roughage component in composite ration under intensive feeding will provide leaner meat which will be better accepted by the consumers and will be economical (Karim and Rawat, 1997; Karim and Patnayak, 1998).

Conclusion

In the present study, the results have shown that, SSB can be included at 60 per cent level in the rations of growing ram lambs for economic meat production since there was no significant improvement observed in feed conversion efficiency and cost per kg gain was reduced compared to those complete diets with 50, 40 and 30 per cent level of SSB.

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Table 1 Ingredient and composition of experimental diets.

Item	Experimental diets			
	CR-I	CR-II	CR-III	CR-IV
Ingredient (%)[a]				
Sweet sorghum bagasse	60	50	40	30
Maize	12.4	15.5	18.6	21.7
Groundnut cake	6.6	8.25	9.9	11.5
Sunflower cake	8	10	12	14
Deoiled rice bran	9.2	11.5	13.8	16.1
Molasses	2	2.5	3	3.5
Urea	0.6	0.75	0.9	1.1
Mineral mixture	0.8	1.0	1.2	1.4
Salt	0.4	0.5	0.6	0.7
Chemical composition (g/kg)[b]				
Crude protein	102.1	116.6	131.2	143.7
NDF	568.9	525.5	480.8	431.1
ADF	324.6	302.2	271.3	243.8

Calcium	10.5	11.2	11.8	11.9
Phosphorus	5.3	5.6	6.1	6.5

[a]Vitamin A, D_3 supplement was added @ 0.1 g/ kg complete diet.
[b]On DM basis
Complete rations (CR) of CR-I, CR-II, CR-III and CR-IV refer to diets with SSB to concentrate ratios of 60:40, 50:50, 40:60 and 30:70, respectively.
NDF: neutral detergent fibre; ADF: acid detergent fibre.

Table 2 Effect of feeding complete diets with different SSB to concentrate ratios on performance of lambs.

Item	Experimental diets				SEM
	CR-I	CR-II	CR-III	CR-IV	
Initial body weight (kg)	10.68	10.65	10.53	10.60	0.25
Final body weight (kg)	24.60	25.37	25.98	26.13	0.37
Metabolic body wt. (kg)	8.60	8.74	8.83	8.87	0.09
Average daily gain (g)	77.31	81.76	85.83	86.30	2.08
Feed intake (g/d)	866.82	847.53	867.45	853.10	13.79
DMI (g/d)	771.93	754.46	777.91	763.53	12.29
DMI (g/kg w $^{0.75}$)	90..307	86.67	88.19	86.16	0.94
Feed conversion ratio (kg feed/kg gain)	11.42	10.57	10.17	9.96	0.28
Cost/kg feed (₹)	5.50	6.53	7.55	8.58	-
Feed cost/kg gain (₹)	62.83^{c}	69.00^{bc}	76.76^{ab}	85.43^{a}	2.40

[a, b, c] values bearing different superscripts in a row differ significantly (P<0.01)
1US $ = ₹ 50

Complete rations (CR) of CR-I, CR-II, CR-III and CR-IV refer to diets with SSB to concentrate ratios of 60:40, 50:50, 40:60 and 30:70, respectively.
DMI Dry matter intake; Metabolic body weight= $w^{0.75}$

Table 3 Effect of feeding complete diets with different SSB to concentrate ratios on carcass characteristics of lambs.

Parameter	Experimental diets				SEM
	CR-I	CR-II	CR-III	CR-IV	
Slaughtering data					
Pre slaughter wt. (kg)	24.5	25.13	24.57	24.27	0.92
Empty body wt. (kg)	20.09	19.47	19.82	19.44	0.77
Carcass wt. (kg)	11.00	10.73	10.73	10.80	0.48
Dressing weight %					
On slaughter wt.	44.90	42.57	43.67	44.42	0.49
On empty body wt.	54.90	55.00	54.10	55.43	0.65
Wholesale cuts (% carcass weight)					
Foreshank and brisket	17.37	18.42	16.64	16.70	0.30
Neck and shoulder	24.70	23.13	25.81	25.50	0.42
Rack	11.20	12.88	10.98	11.66	0.37
Loin	11.81	11.39	11.00	11.32	0.28
Leg	34.92	34.17	35.57	34.83	0.24
Visceral organs (% pre slaughter weight)					
Pluck	3.20	3.36	3.56	3.37	0.09
Liver	1.47	1.56	1.54	1.51	0.03
Kidney	0.26	0.30	0.27	0.27	0.01
Heart	0.46	0.48	0.52	0.47	0.02
Testes	0.52	0.53	0.51	0.41	0.04
GIT(Full)	26.59	29.59	26.54	26.47	0.73
GIT(Empty)	6.83	6.98	7.28	6.84	0.13
Spleen	0.29	0.33	0.34	0.33	0.02
Lungs with trachea	1.27	1.32	1.50	1.39	0.05
Skin (kg)	2.82	2.97	3.11	3.02	0.13
Head (kg)	1.62	1.57	1.60	1.51	0.05
Blood (kg)	0.72	0.74	0.85	0.66	0.04
Composition of carcass (% of carcass)					
Meat	58.15	59.31	59.65	60.10	0.84
Bone	34.06	33.37	33.11	32.38	0.54
Fat	7.80	7.32	7.24	7.52	0.85
B-M ratio	1.71	1.82	1.80	1.87	0.05

Each value is the average of three observations

$P>0.05$

Complete rations (CR) of CR-I, CR-II, CR-III and CR-IV refer to diets with SSB to concentrate ratios of 60:40, 50:50, 40:60 and 30:70, respectively.

GIT Gastro intestinal tract

Table 4 Effect of feeding complete diets with different SSB to concentrate ratios On Chemical composition of *Longissimus dorsi* muscle on fresh basis (%) of lambs.

Nutrient	Complete ration				SEM
	CR-I	CR-II	CR-III	CR-IV	
Moisture	76.61	75.01	73.78	73.49	0.54
Protein	20.74	21.51	21.75	21.70	0.18
Fat	1.02	1.52	1.85	2.52	0.23
Ash	1.63	1.96	2.62	2.29	0.20

Each value is the average of three observations
$P>0.05$
Complete rations (CR) of CR-I, CR-II, CR-III and CR-IV refer to diets with SSB to concentrate ratios of 60:40, 50:50, 40:60 and 30:70, respectively.