

Effect of feeding processed sweet sorghum (*Sorghum bicolor* (L) *moench*) crushed residue based complete ration on growth performance and feeding behavior of murrah buffalo calves

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Abstract

Aim: The objective of the present study is to know the effect of feeding processed sweet sorghum (*Sorghum bicolor* (L) *moench*) crushed residue (SSCR) based complete ration on growth, feeding behavior and cost of gain in Murrah buffalo calves in order to compare the feeding value of SSCR with sorghum straw (SS) and also find out the efficient way of utilization of SSCR in the diets of growing buffalo calves.

Materials and Methods: Experimental complete rations were formulated with SSCR and concentrate in 50:50 ratio and processed in to SSCR chopped and concentrate (SSCRC), mash (SSCRM) and expander extruder pellets (SSCRP). The control ration was SS based complete feed processed in to mash (SSM). 24 Murrah buffalo calves (Average 137 kg body weight and aged 1 year 2 months) were randomly distributed into 4 experimental groups of 6 animals each in a completely randomized design and the experimental rations were offered to 4 groups randomly for a period of 150 days. A 7 day digestion trial was conducted at the end of 150 day growth trial to find out the nutrient digestibility of experimental rations. Eating and ruminating activities were noted every 5 minutes, and each activity was assumed to persist for the entire 5 minutes. Sorting behavior in the calves was observed physically at the time of feeding. The cost of the rations was calculated on the basis of processing cost and the prevailing market prices of the feed ingredients.

Results: The DM intake (g/d), digestibilities of DM, organic matter, crude protein and nitrogen free extract and nitrogen (N) balance were higher ($P < 0.05$) in buffalo calves fed SSCRP ration but, comparable among SSCRC, SSCRM and SSM rations. Higher ($P < 0.01$) average daily gain (g), lower feed conversion ratio (FCR) was observed in calves fed SSCRP ration, while comparable among SSCRC, SSCRM and SSM rations. Eating, rumination and total chewing time (minutes/d, minutes/kg DMI and minutes/kg NDFI) and number of chews for eating, rumination and total chewing (per d, per kg DMI and per kg NDFI) were higher ($P < 0.01$) in calves fed SSCRC ration and lower ($P < 0.01$) in SSCRP ration and comparable among SSCRM and SSM rations. Sorting and selection of ration against large fibrous particles in favour of concentrate portion of the ration was observed in SSCRC ration and was not observed in SSCR, SSCRM and SSM rations. lower ($P < 0.05$) cost (INR) per kg gain was observed in buffalo calves fed SSCRP ration than those fed SSCRC, SSCRM and SSM rations.

Conclusion: The present study indicated that SSCR may be used as roughage source in place of SS in complete feeds for economic feeding of buffalo calves. Further, expander-extruder processing of the complete ration improved feed intake, growth rate, feed efficiency and decreased sorting behavior and cost of feeding compared to mash and chopped forms of the ration.

Keywords: buffalo calves, complete rations, cost economics, feeding behavior, growth, sweet sorghum crushed residue

Introduction

Sweet sorghum (*Sorghum bicolor* (L) *moench*), a dry land crop is more water use efficient and recently gaining importance as a feedstock for ethanol production [1]. In general, it can produce stalk 54 - 69 t/ha [2]. The crushed residue produced after juice extraction from stalks can be used as animal feed [3]. The feed value of the sweet sorghum crushed residue is not less than the value of non-sweet stem that is currently the main stay of feed market in and around Hyderabad [4]. Feeding of roughages under complete diet system improved the palatability and utilization of bulky crop residues [5]. Various processing methods like grinding [6] and pelleting [7] improved the dry matter intake and

digestibility of nutrients. Now a day's expanders are being used in feed industry as an alternative for pelleting for processing of livestock feeds [8,9].

The objective of the present study was to know the effect of feeding processed SSCR based complete ration on growth, nutrient digestibility, feed efficiency, feeding behavior and cost per kg weight gain in Murrah buffalo calves in order to compare the feeding value of SSCR with sorghum straw (SS) and also find out the efficient way of utilization of SSCR in the diets of growing buffalo calves.

Materials and Methods

The variety of sweet sorghum used in the present

Table-1. Ingredient and chemical composition of experimental complete rations

Ingredient/Nutrient	SSM	SSCRC	SSCRM	SSCRP
Ingredient composition (kg/100kg)				
Maize	31.0	31.0	31.0	31.0
Ground nut cake	16.5	16.5	16.5	16.5
Sunflower cake	20.0	20.0	20.0	20.0
Deoiled rice bran	23.0	23.0	23.0	23.0
Molasses	5.0	5.0	5.0	5.0
Urea	1.5	1.5	1.5	1.5
Mineral mixture	2.0	2.0	2.0	2.0
Salt	1.0	1.0	1.0	1.0
Sweet sorghum crushed residue	-	50.0	50.0	50.0
Jowar straw (CSV-5 variety)	50.0	-	-	-
Vitaminutes AD ₃ (g/qt)	20.0	20.0	20.0	20.0
Chemical composition (% DM basis)				
Dry matter	92.36	92.45	92.57	92.38
Organic matter	90.32	90.31	90.23	90.27
Crude protein	11.15	11.55	11.66	11.73
Ether extract	1.34	2.00	1.98	1.99
Crude fibre	27.39	26.85	27.13	26.95
Nitrogen free extract	50.44	49.91	49.46	49.60
Neutral detergent fibre	9.68	9.69	9.77	9.73
Acid detergent fibre	31.11	29.48	30.22	29.67
Hemicellulose	21.43	25.52	22.33	22.80
Cellulose	21.46	23.27	23.66	23.35
Lignin	4.19	3.43	3.94	3.78

*Each value is the average of three observations. On dry matter basis except for dry matter

study was SSV 84 developed by ICRISAT (International Crops research Institute for the Semi Arid Tropics) and propagated by the farmers in Medak District of Andhra Pradesh. The crop was harvested at 135 days after sowing and crushed at the decentralized sweet sorghum crushing unit established by ICRISAT at Ibrahimbad village of Medak District in Andhra Pradesh. The required quantity of SSCR was procured from the crushing unit and sundried for the preparation of experimental rations. Twenty four Murrah buffalo calves with uniform body weight (137 kg) and age (1 year 2 months) were distributed randomly into four experimental groups of six animals each in a completely randomized design. Experimental complete rations were formulated with SSCR and concentrate in 50:50 ratio and processed in to chopped SSCR and concentrate (SSCRC), mash (SSCRM) and expander-extruder pellets (SSCRP). The control diet was formulated using sorghum straw (SS) in the same roughage to concentrate ratio and processed in to mash form (SSM). The complete rations were offered to four groups of buffalo calves randomly for a period of 150 days. The animals were weighed fortnightly for 3 consecutive days before offering feed and water in the morning. A 7 day digestion trial was conducted at the end of 150 day growth trial. The samples were analyzed for proximate principles [10] and fibre fractions [11]. Metabolizable energy (ME) values were calculated from total digestible nutrients (TDN) using factors suggested [12]. Eating and ruminating behavior were monitored visually for a 24 h period in shifts of 8 hours during the last 3 days of the growth trial. Eating and ruminating activities were noted every 5 minutes, and each activity was assumed to persist for the entire 5 minutes. To estimate the time spent for eating, ruminating and total chewing per kg dry matter intake (DMI) and neutral detergent fibre intake (NDFI), the actual intake for that day was used.

A period of rumination was defined as at least 5 minutes of rumination occurring after at least 5 minutes without rumination activity. Total chewing time was determined as the sum of total eating and ruminating times. The number of chews per day was calculated by the following formulas [13].

Eating chews (number day) = $-5854 + 84.75 \times \text{eating time (minutes/d)}$.

Ruminating chews (number per day) = $-81 + 71.29 \times \text{ruminating time (minutes/d)}$.

Total chews (number per d) = $-12390 + 80.59 \times \text{total chewing time (minutes/d)}$.

Sorting behavior of the calves observed physically during feeding of the calves for last three days of the growth trial. Statistical analysis of the data was carried out according to the procedures suggested [14]. The costs of the rations were calculated on the basis of processing cost and the prevailing market prices of the feed ingredients.

Ethical approval: The study was approved by Institutional Animal Ethics Committee on 17th October 2010

Results and Discussion

Chemical composition of SSCR: SSCR on dry matter basis contained 92.5% dry matter (DM), 90.75% organic matter (OM), 3.94% crude protein (CP), 1.89% ether extract (EE), 37.58% crude fibre (CF), 47.34% nitrogen free extract (NFE), 9.2 % total ash (TA), 74.76% neutral detergent fiber (NDF), 42.93% acid detergent fiber (ADF), 31.84% cellulose, 37.75% hemicellulose and 4.24% lignin. The proximate principles of SSCR were comparable with sorghum and maize stovers [15]. The CP per cent of SSCR was comparable with sorghum stover [16].

The NDF and ADF content of sorghum and maize stovers [15] and stripped leaves of sweet sorghum

Table-2. Effect of feeding differently processed sweet sorghum crushed residue based complete rations on nutrient digestibility (%) in murrah buffalo calves

Nutrient	SSM	SSCRC	SSCRM	SSCRP	SE
Intake (unit/kg w^{0.75})					
Dry matter (g)	96.97 ^b	93.46 ^b	93.71 ^b	95.37 ^a	0.83
Water intake (g)	426.50	434.80	420.70	422.50	0.21
Nutrient digestibility					
Dry matter	64.71 ^b	64.60 ^b	64.64 ^b	66.60 ^a	0.20
Organic matter	67.25 ^b	67.66 ^b	67.35 ^b	69.67 ^a	0.31
Crude protein	65.82 ^b	65.99 ^b	66.05 ^b	69.91 ^a	0.47
Ether extract	66.09	67.25	66.24	67.51	0.52
Crude fibre	60.56	60.79	59.82	59.73	0.86
Nitrogen free extract	66.23 ^b	66.30 ^b	66.43 ^b	68.70 ^a	0.34
Neutral detergent fibre	53.87	53.49	53.84	53.62	0.53
Acid detergent fibre	51.55	51.31	51.32	50.75	0.41
Hemicellulose	69.67	70.87	52.49	52.65	0.51
Cellulose	52.97	53.37	52.49	52.65	0.62
Nitrogen intake (g)	82.97 ^b	85.82 ^b	86.22 ^a	88.28 ^a	0.72
Nitrogen Balance (g/d)	26.15 ^b	25.66 ^b	27.45 ^b	33.01 ^a	0.82
Nutritive value of the rations					
Digestible crude protein (%)	7.34 ^b	7.62 ^b	7.70 ^b	8.20 ^a	0.08
Total digestible nutrient (%)	59.33	60.06	59.74	61.40	0.36
Metabolizable energy (MJ)	8.98	9.09	9.04	9.29	0.05

Each value is the average of three observations, a,b: values bearing different superscripts in a row differ significantly ($P < 0.05$)

hybrids [4] were comparable with SSCRC. However, compared to SSCRC, lower values of NDF (52.82%) and ADF (46.51%) content were reported in sorghum stover [16] might be due to difference in stage of harvesting.

The chemical composition of processed SSCRC rations were comparable (Table-1) as the processing does not have any effect on chemical composition among mash and pelleted rations [17].

Dry matter intake: The DMI (g/d) was higher ($P < 0.05$) in buffalo calves fed SSCRP ration, while comparable among SSCRC, SSCRM and SSM rations (Table 2). This might be due to more palatability of pelleted ration resulted into more feed intake of expander-extruder complete diets [5,18].

However, no significant difference was found in water intake among buffalo calves fed different experimental rations.

Nutrient digestibilities: The average DM, OM, CP and NFE digestibilities were higher ($P < 0.05$) in calves fed SSCRP ration, but comparable among SSCRC, SSCRM and SSM rations (Table-2). This might be due to heat treatment of the complete ration during expander-extruder processing which might have protected protein from ruminal degradation resulted for higher CP digestibility and might also helps in gelatinization of the starch components of the feed and loosening of the bonds between lignin and soluble carbohydrates (hemicellulose, xylose etc.) which in turn resulted in higher ($P < 0.05$) energy digestibility [8].

However, significant difference was not observed in the digestibilities of CF and EE and cell wall constituents among the differently processed SSCRC rations and with control ration corroborating the findings [8, 19].

Nitrogen balance: The N intake (g/d) and N balance (g/d) were higher ($P < 0.05$) in calves fed SSCRP ration

compared to those fed SSCRC, SSCRM and SSM rations (Table-2) reflecting CP digestibility pattern among the experimental rations. Higher N balance might be due to better CP digestibility of expander-extruder ration over mash and chopped form of the rations [20]. All the buffalo calves showed positive nitrogen balance.

Nutritive value: Higher ($P < 0.05$) DCP (%) content and intake in buffalo calves fed SSCRP ration (Table 2) might be due to higher ($P < 0.05$) digestibility and intake of CP due to expander-extruder processing [5]. The trend of TDN (%) and ME (MJ/kg DM) content and intake of SSCRP ration was similar to that of DCP (%) content and intake but the difference among the rations were not significant. All the buffalo calves fed differently processed complete rations met the DM, DCP and TDN requirements recommended [21].

Feeding behavior: Eating, rumination and total chewing time (minutes/d, minutes/kg DMI and minutes/kg NDFI) and number of chews for eating, rumination and total chewing (per d, per kg DMI and per kg NDFI) were higher ($P < 0.01$) in buffalo calves fed SSCRC ration compared to those fed SSCRM, SSCRP and SSM rations and lower ($P < 0.01$) in calves fed SSCRP ration compared to those fed SSCRC, SSCRM and SSM rations. This might be due larger particle size and less dense nature of the SSCRC ration compared to SSCRP, SSCRM and SSM rations. Lower eating and chewing time in buffalo calves fed SSCRP ration might be due to easier consumption of the pellets [19] resulting on higher intakes [18]. The rumination time per unit DM intake decreased with decreasing dietary particle size [22] in cattle corroborates with the present findings of lower rumination in SSCRP followed by SSCRM and SSM rations.

However, the difference in time required and number of chews for eating, rumination and total chewing were not significant in buffalo calves fed SSCRM and SSM

Table-3. Effect of feeding processed sweet sorghum crushed residue based complete rations on eating and rumination in murrh buffalo calves

Parameter	Ration				Mean \pm SEM
	SSM	SSCRC	SSCRM	SSCRP	
Eating					
Minutes/d	237.00 ^b	256.80 ^a	236.30 ^b	196.00 ^c	231.50 \pm 5.72
Minutes/kg DMI	51.97 ^b	57.37 ^a	51.30 ^b	41.67 ^c	50.57 \pm 1.54
Minutes/Kg NDFI	96.61 ^b	108.98 ^a	92.01 ^b	79.11 ^c	94.17 \pm 2.90
No. of chews/d	9892.55 ^b	12274.03 ^a	9799.33 ^b	7316.15 ^c	9820.51 \pm 454.02
Chews/kg DMI	2168.60 ^b	2743.84 ^a	2127.86 ^b	1555.82 ^c	2149.03 \pm 111.05
Chews/kg NDFI	4031.60 ^b	5212.47 ^a	3816.11 ^b	2953.34 ^c	4003.38 \pm 212.82
Ruminating					
Minutes/d	480.50 ^b	514.00 ^a	481.50 ^b	401.50 ^c	469.38 \pm 10.77
Minutes/kg DMI	105.36 ^b	114.87 ^a	104.56 ^b	85.39 ^c	102.54 \pm 2.96
Minutes/Kg NDFI	195.88 ^b	218.23 ^a	187.51 ^b	162.09 ^c	190.92 \pm 5.56
No. of chews/d	22520.50 ^b	26256.10 ^a	22327.90 ^b	18332.20 ^c	22359.18 \pm 724.62
Chews/kg DMI	4938.09 ^b	5867.74 ^a	4847.90 ^b	3897.55 ^c	4887.82 \pm 186.07
Chews/kg NDFI	9180.32 ^b	11146.93 ^a	8694.23 ^b	7398.53 ^c	9105.00 \pm 358.65
Total chewing					
Minutes/d	717.50 ^b	770.80 ^a	717.80 ^b	597.50 ^c	700.86 \pm 16.45
Minutes/kg DMI	157.33 ^b	172.24 ^a	155.86 ^b	127.06 ^c	153.12 \pm 4.49
Minutes/Kg NDFI	292.49 ^b	327.21 ^a	279.52 ^b	241.19 ^c	285.10 \pm 8.44
No. of chews/d	32413.03 ^b	38600.02 ^a	32127.32 ^b	25648.34 ^c	32197.17 \pm 1183.29
Chews/kg DMI	7106.69 ^b	8625.52 ^a	6975.77 ^b	5453.37 ^c	7040.34 \pm 297.14
Chews/kg NDFI	13211.92 ^b	16385.87 ^a	12510.34 ^b	10351.87 ^c	13115.00 \pm 571.65

Each value is the average of four observations, a, b: values bearing different superscripts in a row differ significantly ($P < 0.01$)

Table-4. Effect of feeding differently processed sweet sorghum crushed residue based complete rations on growth rate, feed efficiency and cost economics in Murrah buffalo calves

Parameter	SSM	SSCRC	SSCRM	SSCRP	SE
Initial Weight (kg)	136.90	137.00	137.30	136.90	0.37
Final weight (kg) **	209.60 ^b	205.20 ^b	209.70 ^b	224.70 ^a	2.56
Weight gain (kg) **	72.70 ^b	68.20 ^b	72.40 ^b	87.80 ^a	2.05
Average daily gain (g/d)**	484.67 ^b	454.66 ^b	482.67 ^b	585.33 ^a	13.67
Feed intake (kg/d) *	4.50 ^{ab}	4.42 ^b	4.49 ^{ab}	4.56 ^a	0.02
Feed conversion Ratio (kg/kg gain)**	9.29 ^b	9.84 ^b	9.36 ^b	7.80 ^a	0.23
Cost/kg gain (Rs) **	74.55 ^a	63.22 ^b	61.07 ^b	52.44 ^c	4.55

Each value is the average of six observations, a, b: values bearing different superscripts in a row differ significantly ($P < 0.01$)

rations (Table-3) because of the similar physical properties of the complete rations.

Sorting and selection of ration against longer particles of SSCR in favour of smaller particles of the concentrate portion of the ration was observed in calves fed SSCRC ration compared to SSCR, SSCR and SSM rations. Similar findings were reported in Holstein Friesian heifers [23] and cattle [24]. However, sorting was not observed in SSCR, SSCR and SSM rations. Sorting of the complete ration can be prevented by pelleting and grinding of the feed [25].

Growth rate and cost economics: The higher ($P < 0.05$) feed intake and higher ($P < 0.01$) average daily gain (g) in buffalo calves fed SSCR ration (Table-4) might be due to easier consumption of pelleted ration and efficient digestibility of nutrients [8] compared to chopped form of the ration. Even though the average daily feed intake (kg/d) among SSCR, SSCR and SSM rations were not significantly different, higher (1.32%) daily feed intake (kg/d) in buffalo calves fed SSCR ration was observed compared to SSCR and SSM rations.

The FCR and cost per kg gain (INR) was lower ($P < 0.01$) in buffalo calves fed SSCR ration compared to those fed SSCRC, SSCR and SSM rations (Table-4). This might be due to efficient digestibility of DM,

OM, CP and NFE in buffalo calves fed SSCR ration than those fed SSCRC, SSCR and SSM rations corroborating the findings [17]. Even though FCR was not significant in buffalo calves fed either SSM or SSCRC and SSCR rations, the cost/kg gain (INR) was lower ($P < 0.01$) in buffalo calves fed SSCR and SSCRC rations than those fed SSM ration due to higher cost of sorghum straw (INR-4) compared to SSCR (INR-1).

Conclusion

Based on the results of the present study it was concluded that SSCR may be used as roughage source in place of SS in complete feeds for economic growth rate in buffalo calves. Further, expander-extruder processing of the complete ration improved feed intake, growth rate, feed efficiency and decreased sorting behavior and cost of feeding compared to mash and chopped forms of the ration.

Author's contribution

CVS, SJR, YRR and DN implemented the study design. CVS and MM recorded and analysed the data. CVS, SJR, YRR and DN drafted and revised the manuscript. All author read and approved the final manuscript

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Competing interests

Authors declare that they have no competing interest.

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