

EFFECT OF FEEDING DIFFERENTLY PROCESSED SWEET SORGHUM BAGASSE BASED COMPLETE RATIONS ON FEEDING BEHAVIOUR, MILK PRODUCTION AND COST ECONOMICS IN GRADED MURRAH BUFFALOES

Ch. Venkata Seshaiyah*, S. Jagadeeswara Rao, Y. Ramana Reddy,
M. Mahendar and M. Kishan Kumar

ABSTRACT

The effect of feeding differently processed sweet sorghum (*Sorghum bicolor* (L.) moench) bagasse (SSB) based complete rations on feeding behaviour, milk production and cost economics was studied in 24 lactating graded Murrah buffaloes distributed into four experimental groups of six buffaloes each in a completely randomized design. Experimental complete rations were formulated with SSB and concentrate (50:50) and processed into SSB chopped and concentrate (SSBC), mash (SSBM) and expander extruder pellets (SSBP). The control ration was sorghum straw based complete feed mash (SSM). The eating, rumination and total chewing time (min/d, min/kg DMI and min/kg NDFI) and number of chews for eating, rumination and total chewing (per d, per kg DMI and per kg NDFI) were significantly ($P<0.01$) higher in the buffaloes fed the SSBC ration and significantly ($P<0.01$) lower in buffaloes fed the SSBP ration and comparable among SSBM and SSM rations. The milk yield, 6% fat corrected milk (FCM) yield (kg/d) and total solids, solids not fat (SNF), milk fat and protein yield (g/d) were significantly ($P<0.05$) higher in buffaloes fed SSBP ration and not significant among SSBC, SSBM and SSM rations. The feed conversion ratio (kg/kg milk yield and kg/kg FCM yield) and cost of feed (₹) per kg milk yield and per kg FCM yield was significantly

($P<0.05$) lower in the buffaloes fed the SSBP ration compared to the SSBC, SSBM and SSM rations, while the difference was not significant among SSBC, SSBM and SSM rations. Hence, SSB can be used as an alternative roughage source to sorghum straw economically in ruminant rations.

Keywords: sweet sorghum bagasse, complete rations, buffaloes, feeding behaviour, milk production

INTRODUCTION

Sweet sorghum (*Sorghum bicolor* (L.) moench), a dry land crop, is more water use efficient and has recently been gaining importance as a feedstock for ethanol production (Reddy *et al.*, 2005). In general, it can produce stalk 54 - 69 t/ha (Almodares *et al.*, 2008). The bagasse produced after juice extraction from stalks can be used as animal feed (Jafarinia *et al.*, 2005). The feed value of the sweet sorghum bagasse is not less than the value of non-sweet stem that is currently the mainstay of the feed market in and around Hyderabad, India (Blümmel *et al.*, 2009). Feeding of roughages under complete diet systems improved the palatability and utilization of bulky crop residues (Nagalakshmi *et al.*, 2006). Various processing methods like grinding (Reddy *et al.*,

Department of Livestock Production and Management, College of Veterinary Science, Sri Venkateswara Veterinary University, Rajendranagar, Hyderabad, 500 030, India , *E-mail: seshuchappidi@yahoo.com

1992) and pelleting (Reddy, 1990) improved the DM intake and digestibility of nutrients. Nowadays expanders are being used in the feed industry as an alternative to pelleting for processing livestock feeds (Prasad, 2003 and Nagalakshmi *et al.*, 2006). Even though buffaloes are the efficient utilizers of poor quality roughages, information on the effect of feeding differently processed SSB based complete rations on feeding behaviour and milk production performance of graded buffaloes is not available. Hence, an attempt has been made to evaluate SSB as a sole roughage source in a complete diet processed into varied forms like chopping, grinding into mash and expander-extruder pelleting and study the effect of processing on eating, rumination, milk production and cost economics in lactating graded Murrah buffaloes.

MATERIALS AND METHODS

Twenty-four lactating graded Murrah buffaloes in their above early stage of lactation with an average of 3.0 lactations and weighing about 450 kg were selected from the Dairy Experimental Station, College of Veterinary Science, Rajendranagar, Hyderabad, India and distributed randomly into four experimental groups of six animals each in a completely randomized design (CRD) considering body weight, number of lactations, stage of lactation, daily average milk yield and butter fat content, as uniform as possible at the start of experiment. Experimental complete rations were formulated with SSB and concentrate in a roughage:concentrate ratio of 50:50 (Table 1) and processed into chopped SSB and concentrate (SSBC), SSB based complete diet in mash form (SSBM) and in 16 mm expander-extruder pellet form (SSBP). The control diet was formulated

using sorghum straw (SS) and concentrate in a roughage:concentrate ratio of 50:50 and processed into mash form (SSM) at the feed processing plant, Department of Animal Nutrition, College of Veterinary Science, Rajendranagar, Hyderabad, India. The experimental rations SSM, SSBC, SSBM and SSBP were randomly allotted to the four groups of lactating buffaloes and fed the animals three times per day (d) i.e. about half an hour before milkings at 04.00 and 16.00 h and one time at 10.00 h in-between the milkings for a period of 150 d. Daily feed intake, water intake and milk yields were recorded. Eating and ruminating behaviours were monitored visually for a 24 h period (three shifts of 8 h) during last three d of lactation 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 d 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 (TC) time was determined as the sum of total eating and ruminating times. The number of chews per d was calculated by the following formulas developed by Allen (1997). Eating chews (number day) = $-5854 + 84.75 \times \text{eating time (min/d)}$. Ruminating chews (number per d) = $-81 + 71.29 \times \text{ruminating time (min/d)}$. Total chews (number per d) = $-12390 + 80.59 \times \text{total chewing time (min/d)}$.

The milk samples were collected fortnightly during the lactation trial to evaluate quality and quantity of milk constituents. Milk samples were analyzed for fat (ISI, 1961) solids not fat (SNF) (ISI, 1965) methods and protein estimation by 'Turbotherm' and Vapodest' (Gerhard, Germany) analyzer based on the principle of Micro-Kjeldahl

Table 1. Ingredient composition (%) of experimental complete rations.

Ingredient	SSM	SSBC	SSBM	SSBP
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 bagasse	-	50.00	50.00	50.00
Jowar straw	50.00	-	-	-

Table 2. Effect of feeding differently processed sweet sorghum bagasse based complete rations on eating and rumination in lactating graded Murrah buffaloes.

Parameter	Ration				Mean±SEM
	SSM	SSBC	SSBM	SSBP	
Eating					
Min/d	204.50 ^b	237.80 ^a	205.00 ^b	177.80 ^c	5.51
Min/kg DMI	14.90 ^b	17.40 ^a	14.83 ^b	12.60 ^c	0.44
Min/Kg NDFI	27.71 ^b	33.06 ^a	26.59 ^b	23.91 ^c	0.86
No. of chews/d	11477.38 ^b	14295.31 ^a	11519.75 ^b	9210.31 ^c	466.99
Chews/kg DMI	836.41 ^b	1046.52 ^a	833.15 ^b	652.70 ^c	36.13
Chews/kg NDFI	1554.95 ^b	1987.98 ^a	1494.17 ^b	1238.99 ^c	69.75
Ruminating					
Min/d	404.80 ^b	478.00 ^a	405.50 ^b	366.00 ^c	10.46
Min/kg DMI	29.50 ^b	44.40 ^a	29.33 ^b	25.94 ^c	2.81
Min/Kg NDFI	54.84 ^b	66.47 ^a	52.60 ^b	49.23 ^c	1.68
No. of chews/d	24573.63 ^b	29795.62 ^a	24627.10 ^b	21811.14 ^c	745.94
Chews/kg DMI	1790.88 ^b	2181.16 ^a	1781.11 ^b	1545.63 ^c	58.94
Chews/kg NDFI	3329.39 ^b	4143.53 ^a	3194.25 ^b	2933.99 ^c	116.85
Total chewing					
Min/d	609.30 ^b	715.80 ^a	610.50 ^b	543.80 ^c	15.93
Min/kg DMI	44.40 ^b	52.40 ^a	44.15 ^b	38.53 ^c	1.28
Min/Kg NDFI	82.54 ^b	99.54 ^a	79.19 ^b	73.14 ^c	2.53
No. of chews/d	36051.00 ^b	44106.82 ^a	36146.85 ^b	31021.45 ^c	1210.92
Chews/kg DMI	2627.29 ^b	3228.77 ^a	2614.26 ^b	2198.33 ^c	94.93
Chews/kg NDFI	4884.34 ^b	6133.73 ^a	4688.42 ^b	4172.98 ^c	186.26

Each value is the average of six observations.

^{abc}values bearing different superscripts in a row differ significantly (P<0.01).

Table 3. Effect of feeding differently processed sweet sorghum bagasse based complete rations on quality and quantity of milk production in lactating graded Murrah buffaloes.

Parameter	SSM	SSBC	SSBM	SSBP	Average ±SEM
Milk yield (kg/d)	5.29 ^b	5.17 ^b	5.54 ^b	6.91 ^a	0.20
6% FCM yield (kg/d)	6.29 ^b	6.24 ^b	6.51 ^b	7.74 ^a	0.20
Total solids (%)	17.73	18.20	18.02	17.62	0.23
Solids not fat (%)	10.38	10.58	10.59	10.50	0.11
Milk fat (%)	7.35	7.61	7.43	7.04	0.16
Milk protein (%)	4.32	4.30	4.38	4.44	0.03
Milk constituents yield (g/d)					
Total solids	937.92 ^b	940.94 ^b	998.31 ^b	1217.54 ^a	4.20
Solids not fat	549.10 ^b	546.99 ^b	546.69 ^b	731.08 ^a	3.45
Milk fat	388.82 ^b	393.44 ^b	411.62 ^b	486.46 ^a	2.43
Milk protein	228.53 ^b	226.45 ^b	242.65 ^b	306.80 ^a	1.80

Each value is the average of six observations.

^{a,b}values bearing different superscripts in a row differ significantly (P<0.05).

Table 4. Effect of feeding differently processed sweet sorghum bagasse based complete rations on feed conversion ratio and cost of milk production in lactating graded Murrah buffaloes.

Parameter	SSM	SSBC	SSBM	SSBP	SEM
Feed intake (kg/d)	12.04 ^a	11.76 ^b	12.13 ^a	12.16 ^a	0.10
Feed conversion ratio (kg/kg milk yield)	2.28 ^b	2.27 ^b	2.19 ^b	1.76 ^a	0.01
Feed conversion ratio (kg/kg FCM)	1.91 ^b	1.88 ^b	1.86 ^b	1.57 ^a	0.12
Cost of feed (₹/d)	96.62 ^a	75.56 ^c	79.15 ^b	81.78 ^b	0.22
Cost of feed/ kg milk (₹)	18.26 ^a	14.61 ^b	14.29 ^b	11.83 ^c	0.07
Cost of feed/ kg FCM (₹)	15.36 ^a	12.11 ^b	12.16 ^b	10.57 ^c	0.06

Each value is the average of six observations.

^{a,b}values bearing different superscripts in a row differ significantly (P<0.05).

method (AOAC, 1997; procedure No. 4.2.02). The costs of the rations were calculated on the basis of processing cost and the prevailing market prices of the feed ingredients. The data was analyzed using the 't' test (Snedecor and Cochran, 1994).

RESULTS AND DISCUSSION

The eating, rumination and total chewing times (min/d, min/kg DMI and min/kg NDFI) and number of chews for eating, rumination and total chewing (per d, per kg DMI and per kg NDFI) were significantly ($P<0.01$) higher in lactating graded Murrah buffaloes fed the SSBC ration compared to those fed the SSBM, SSBP and SSM rations and significantly ($P<0.01$) lower in buffaloes fed the SSBP ration compared to those fed the SSBC, SSBM and SSM rations and comparable among the SSBM and SSM rations (Table 2).

Higher ($P<0.01$) eating, rumination and total chewing times and greater number of chews for eating, rumination and total chewing in buffaloes fed the SSBC ration might be due the larger particle size and less dense nature of the ration compared to the SSBP, SSBM and SSM rations corroborating the findings of Yang and Beauchemin (2009) in lactating dairy cows fed different chop lengths of alfalfa hay based total mixed rations. Lower eating and chewing time in lactating buffaloes fed the SSBP ration might be due to easier consumption of the pellets (Islam *et al.*, 2000) resulting on higher intakes (McDonald *et al.*, 2002). The rumination time per unit DM intake decreasing with decreasing dietary particle size as reported by Beauchemin *et al.* (2003), Mertens (2000), Yang *et al.* (2001) in cattle corroborates the present findings of lower rumination in the SSBP followed by the SSBM and SSM rations. The level of intake also affects

chewing time as the animals that eat high levels of feed spent less time eating and ruminating per unit of feed (Kovacs *et al.*, 1997).

The milk yield and 6% FCM yield (kg/d) was significantly ($P<0.05$) higher in the buffaloes fed the SSBP ration than those fed the SSBC, SSBM and SSM rations (Table 3). The increased milk production might be due to higher DM intake and efficient digestibility of nutrients in lactating graded Murrah buffaloes fed the SSBP ration than those fed the SSBC, SSBM and SSM rations. The heat treatment during expander-extruder processing might have protected protein from ruminal degradation (Glimp *et al.*, 1967; Broderic, 1975), and it 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 in buffaloes in comparison to those fed conventional diets (Nagalakshmi *et al.*, 2004). Higher ($P<0.01$) milk yield (4% FCM) in lactating graded Murrah buffaloes fed cotton straw based expander-extruder complete pellets over conventional ration (Nagalakshmi *et al.*, 2004) and 5.61 and 7.37 per cent higher 4% FCM and fat yield, respectively in Murrah buffaloes fed maize cob based complete pellets than those fed conventional ration (Reddy *et al.*, 2001a) have been reported. The findings of Khan *et al.* (2010) in cross bred milch cows fed on wheat straw based complete pelleted ration (12.75% higher milk and 14% higher FCM) over those fed on conventional ration also corroborate the present findings.

However, the total solids, solids not fat, milk fat and protein per cent in the buffaloes fed differently processed SSB complete rations and SS complete mash were comparable among all the rations. Significant difference was not

observed in fat and SNF % in Murrah buffaloes fed sugarcane bagasse based expander-extruder pelleted ration over conventional ration (Nagalakshmi and Narasimha Reddy, 2010), and comparable fat % in lactating graded Murrah buffaloes fed maize cob based expander-extruder and conventional ration (Reddy *et al.*, 2001b) have been reported.

The daily average total solids, solids not fat (SNF), milk fat and protein yield (g/d) were significantly ($P<0.05$) higher in buffaloes fed the SSBP ration than in those fed the SSBC, SSBM and SSM rations while, the difference in daily average total solids, solids not fat (SNF), milk fat and protein yield (g/d) was not significant among the SSBC, SSBM and SSM rations (Table 4). This might be due to higher average daily milk yield and 6% FCM yield (kg/d) over the SSBC, SSBM and SSM rations. Higher ($P<0.05$) fat yield in lactating graded Murrah buffaloes fed cotton straw based expander-extruder ration over conventional ration was reported (Nagalakshmi *et al.*, 2004)

The feed conversion ratio (kg/kg milk yield and kg/kg FCM yield) was significantly ($P<0.05$) lower in lactating buffaloes fed the SSBP ration compared to the SSBC, SSBM and SSM rations, while the difference in feed conversion ratio (kg/kg milk yield and kg/kg FCM yield) was not significantly different among SSBC, SSBM and SSM rations (Table 4). This might be due to efficient utilization of nutrients in buffaloes fed the SSBP ration resulting higher milk yield, 6% FCM yield (kg/d) over SSBC, SSBM and SSM rations. A 21.99% lower DM intake/kg FCM production in lactating graded Murrah buffaloes fed cotton straw based expander-extruder complete pellets over conventional ration reported by Nagalakshmi *et al.* (2004) corroborate the present findings.

The cost of feed (₹)[rupees] per kg milk

yield and per kg FCM yield was significantly ($P<0.05$) lower in the SSBP ration compared to the SSBC, SSBM and SSM rations while, cost of feed (₹) per kg milk yield and per kg FCM yield was not significantly different among the SSBC and SSBM complete rations (Table 4). This might be due to higher feed efficiency of the SSBP ration over the SSBC, SSBM and SSM rations. Similarly, higher ($P<0.05$) cost of feed (₹) per kg milk yield and per kg FCM yield in the lactating buffaloes fed the SSM ration might be due to the lower feed efficiency of the ration compared to the SSBP ration and higher cost of sorghum straw (₹ 4) compared to SSB (₹ 1). Lower daily cost of feeding in lactating buffaloes fed a sugarcane bagasse based expander-extruder pelleted ration (₹ 51.43) compared to conventional ration (₹ 73.66) (Nagalakshmi and Narasimha Reddy, 2010) and lower cost of feed/kg 4% FCM production ($P<0.01$) in extruded complete diet (₹ 5.60) compared to conventional ration (₹ 8.42) in lactating graded Murrah buffaloes fed maize cob based complete rations (Reddy *et al.*, 2001b) have been reported.

CONCLUSION

The present study indicated that SSB can be used as an alternative roughage source to sorghum straw economically and feeding of complete rations in the form of expander-extruder pellets proved superior in milk production and lowered the time required for eating and rumination, thereby reducing the energy spent on eating and chewing over chopped and mash forms in graded Murrah buffaloes.

ACKNOWLEDGEMENTS

The authors are thankful to the NAIP-ICRISAT Project for the financial support and are also thankful to the management of the Dairy Experimental Station, College of Veterinary Science, Rajendranagar, India for providing the required number of lactating graded Murrah buffaloes and facilities to carry out this work.

REFERENCES

- Allen, M.S. 1997. Relationship between fermentation acid production in the rumen and the requirement for physically effective fibre. *J. Dairy Sci.*, **80**: 1447-1462.
- Almodares, A., R. Taheri and S. Adeli. 2008. Stalk yield and carbohydrate composition of sweet sorghum (*Sorghum bicolor* (L.) Moench) cultivars and lines at different growth stages. *J. Malaysian Appl. Biol.*, **37**: 31-36.
- OAC. 1997. *Association of Official Analytical Chemist, Official Method of Analysis*, 16th ed. Association of Official Analytical Chemist, Washington, D.C., USA.
- Beauchemin, K.A., W.Z. Yang and L.M. Rode. 2003. Effects of particle size of alfalfa-based dairy cow diets on chewing activity, ruminal fermentation, and milk production. *J. Dairy Sci.*, **86**: 630-643.
- Blümmel, M., S.S. Rao, S. Palaniswami, L. Shah and B.V.S. Reddy. 2009. Evaluation of sweet sorghum (*Sorghum bicolor* (L.) Moench) used for bio-ethanol production in the context of optimizing whole plant utilization. *Anim. Nutr. Feed Techn.*, **9**: 1-10.
- Broderic, G.A. 1975. Factors effecting ruminant responses to protected amino acids, p. 211-259. In Friedman, M. (ed.) *Nutritional Quality of Foods and Feeds, Part 2*. Marcel Dekker, New York, USA.
- Glimp, H.A., M.A. Karr, C.O. Little, P.G. Woolflock, G.E. Michell and L.W. Hudson. 1967. Effect of reducing soyabean protein solubility by dry heat on the protein utilization of young lambs. *J. Anim. Sci.*, **26**: 858-861.
- ISI. 1977. IS 1224 (Part I). *Fat determination of milk by Gerber's method*. Indian Standards Institution, New Delhi.
- ISI. 1982. IS: 10083. *Method of test for determination of SNF (Solids not fat) in milk by the use of lactometer*. Indian Standards Institution, New Delhi.
- Islam, M., I. Dahlan and M.A. Rajion. 2000. Effects of Ensiling and Pelleting on Nutrient Utilization of Oil Palm (*Elaeis guineensis*) Frond by Goats. *Asian Austral. J. Anim.*, **13**: 133-136.
- Jafarinia, M., A. Almodares and M. Khorvash. 2005. Using sweet sorghum bagasse in silo. In *Proceedings of 2nd Congress of Using Renewable Sources and Agric. Wastes*. Khorasgan Azade University, Isfahan, Iran.
- Khan, S.R., S.K. Singh and Mudgal Vishal. 2010. Effect of feeding complete rations on the performance of lactating cross breed cows. *Indian J. Anim. Nutr.*, **27**: 261-264.
- Kovacs, P.L., K.H. Sudekum and M. Stangassinger. 1997. Effects of intake level of a mixed diet on chewing activity and on particle size of ruminated boli, ruminal digesta fractions and faeces of steers. *Reprod. Nutr. Dev.*, **37**: 517-528.
- McDonald, P., R.A. Edwards, J.D.F. Greenhalgh and C.A. Morgan. 2002. *Animal Nutrition*,

- 6th ed. Edinburgh, UK: Pearson Education Ltd. Mertens, D.R. 1997. Creating a System for Meeting the Fibre Requirements of Dairy Cows. *J. Dairy Sci.*, **80**: 1463-1481.
- Nagalakshmi, D. and D. Narasimha Reddy. 2010. Effect of feeding expander-extruder processed complete diet containing sugar cane bagasse on performance of Murrah buffaloes. *Anim. Nutr. Feed Techn.*, **10**: 1-8.
- Nagalakshmi, D., D. Narasimha Reddy and M. Kishan Kumar. 2004. Performance of Murrah buffaloes fed expander-pelleted cotton straw based diets. *Anim. Nutr. Feed Techn.*, **10**: 1-8.
- Nagalakshmi, D., D. Narasimha Reddy and M.R. Prasad. 2006. Evaluation of expander-extruder processed complete diet containing sunflower heads in lactating cross breed cows: An on farm trial. *Indian J. Dairy Sci.*, **59**: 233-238.
- Prasad, D.A. 2003. Extrusion-expansion applications in the feed industry, p. 102-108. In Short Term Course on Feed Technology, Acharya N.G. Ranga Agricultural University, Hyderabad, India. Reddy, B.V.S., S. Ramesh, P.S. Reddy, B. Ramaiah, P.M. Salimath and R. Kachapur. 2005. Sweet sorghum - a potential alternative raw material for bio- ethanol and bio - energy. *International Sorghum and Millets News Letter*, **46**: 79-86.
- Reddy, G.V.N., K. Joji Reddy and D. Nagalakshmi. 2001a. Nutrient utilization and rumen fermentation pattern of sugar cane bagasse based complete diets in buffalo bulls. *Indian J. Anim. Nutr.*, **18**: 138-145.
- Reddy, G.V.N., K. Joji Reddy and D. Nagalakshmi. 2001b. Effect of feeding expander extruder processed complete diet containing maize cobs on production performance of buffaloes. *Indian J. Anim. Nutr.*, **18**: 8-14.
- Reddy, M.R. 1990. Complete diets based on fibrous crop residues for dairy cattle. *Indian Dairyman*, **42**: 180-184.
- Reddy, M.R., T. Govindaiah and G.V.N. Reddy. 1992. Effect of physical processing on the nutritive value and nutrient utilization of cotton straw in goats, p. 194. In *Proceedings of 5th International Conference on Goats*, New Delhi, India. Snedecor, G.W. and W.G. Cochran. 1994. *Statistical Methods*, 8th ed. Iowa State University Press, Ames, Iowa, USA.
- Yang, W.Z. and K.A. Beauchemin. 2009. Increasing physically effective fibre content of dairy cow diets through forage proportion versus forage chop length: Chewing and ruminal pH. *J. Dairy Sci.*, **92**: 1603-1615.
- Yang, W.Z., K.A. Beauchemin and L.M. Rode. 2001. Barley processing, forage: Concentrate and forage length effects on chewing and digesta passage in lactating cows. *J. Dairy Sci.*, **84**: 2709-2720.