

PERFORMANCE OF MURRAH BUFFALOES FED SUNFLOWER HEADS BASED COMPLETE DIETS IN TERMS OF NUTRIENT UTILIZATION AND RUMEN FERMENTATION PATTERN

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**ABSTRACT**

An experiment was conducted to study the effect of feeding expander extruder processed sunflower head (SFH) based complete diets incorporated at 40 and 50% and compared with conventional ration (concentrate mixture to meet protein requirements for maintenance and ad lib sorghum straw). These three rations were fed to fistulated buffaloes in a 3 x 3 Latin square design. A 6d metabolic trial was conducted each time after a preliminary feeding period of 21 days and rumen liquor was collected after each trial for 3 consecutive days, 5 times a day, before feeding (0 h) and at 2 h intervals after feeding (2, 4, 6 and 8 h) to assess nutrient utilization and rumen fermentation pattern. The organic matter, crude protein, ether extract, crude fibre, acid detergent fibre and cellulose ( $P<0.05$ ) digestibilities were higher ( $P<0.01$ ) in animals fed either of the complete diets compared to conventional feeding. The buffaloes fed the 40% SFH diet digested higher ( $P<0.01$ ) dry matter, energy and neutral detergent fibre ( $P<0.05$ ) compared to the conventional group. The calcium balance was comparable, while phosphorus ( $P<0.01$ ) and nitrogen ( $P<0.05$ ) balances were higher on the 40% SFH diet compared to the conventional diet and intermediate on the 50% SFH diet. The ruminal pH was lower ( $P<0.01$ ), while total volatile fatty acids, total nitrogen and

TCA precipitable nitrogen was higher ( $P<0.01$ ) with the SFH diets than the conventional diet. The ammonia nitrogen was higher in the 40% SFH diet fed animals compared to the other two diets. The results of this study indicated that SFH could form a roughage source for ruminants by incorporating in an expander extruder processed complete diet at either the 40 or 50% level. Out of these two complete diets, the expander extruder processed complete diet containing 40% SFH proved better in terms of nutrient utilization and rumen fermentation pattern.

**Keywords:** Murrah buffaloes, *Bubalus bubalis*, sunflower heads, nutrient utilization, rumen fermentation, buffaloes, expander extruder

**INTRODUCTION**

In India, a huge gap exists between demand and supply of feed resources for livestock feeding, which is to the tune of 10% for dry fodder, 35% for concentrates and 33% for green fodder and could further increase to 11, 45 and 35%, respectively by the year 2020 (Ramachandra *et al.*, 2007). The efficient use of available feed resources (crop residues and agro-industrial by-products, grains and oil seed meals) along with employing suitable feed processing techniques could greatly help to

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bridge the gap between nutrient availability and nutrient requirements. One such crop residue is deseeded sunflower heads (SFH); this byproduct of the sunflower crop is available in huge quantities after deseeding of sunflowers. About  $765 \times 10^3$  metric tons of SFH is estimated to be available in India for livestock feeding. SFH contains about 7.43% crude protein (CP) and 63.67% total digestible nutrients (TDN) (Madan Mohan *et al.*, 1997). In spite of higher nutritive value compared to conventionally used straws, presently most of the SFH is either used as manure or burnt in fields (Nagalakshmi *et al.*, 2003). *In situ* and *in-vitro* studies revealed that SFH could be incorporated in complete diets either as the sole roughage source at 40% level or at the 50% level in combination with 10% sorghum straw (Nagalakshmi *et al.*, 2005). Further, expander extruder processing of crop residues based complete diets increased nutrient utilization, palatability and reduced cost of feeding in ruminants (Nagalakshmi *et al.*, 2010). Thus the present study was conducted to evaluate complete diets containing 40 or 50% SFH selected from *in-vitro* studies and processed with an expander-extruder in terms of nutrient utilization and rumen fermentation pattern in buffaloes.

## MATERIALS AND METHODS

### Processing of experimental diets

Two complete diets were formulated with 40 and 50% SFH in a roughage concentrate ratio of 40:60 and 60:40, respectively (Table 1). The SFH and concentrate ingredients except for molasses and micro ingredients were first proportioned and batched for 100 kg as per the formula. They were then ground in a hammer mill with an 8mm sieve. The ground material was conveyed to a

horizontal mixer. The mineral mixture and vitamin supplements were prepared in a premix and added directly into the mixer. The preheated molasses was added in the mixer while mixing and then mixed for 10 minutes to obtain complete feed in mash form. The complete feed containing approximately 13.0% moisture was processed in an expander-extruder by the procedure standardized by Nagalakshmi *et al.* (2007). The mash feed was conditioned with steam pressure of 0.6-1.0 kg/cm<sup>2</sup> for the 40% SFH diet and 1.0-1.2 kg/cm<sup>2</sup> for the 50% SFH diet, then passed through a single continuous barrel of the expander-extruder, where the feed was pushed forward and extruded through a die hole of 16mm diameter fitter at other end of the barrel. At the last section of the barrel, the temperature of 85-90°C was achieved and here the feed was subjected heating for about 30 seconds before extruding out. The hot pellets were cooled in a batch cooler and stored in gunny bags.

### Experimental diets

The deseeded SFH procured from nearby sunflower fields was sun dried and used as the main roughage source in the complete diets. The experimental diets were 1. Expander-extruder processed complete diet containing 40% SFH, 2. Expander-extruder processed 50% SFH along with 10% sorghum straw and 3. Conventional diet comprising concentrate mixture offered to meet the protein requirements for maintenance and sorghum straw available *ad libitum*. The ingredient composition of all three diets is given in Table 1.

### Animals, feeding regime and housing management

Three adult male graded Murrah buffaloes (328.5 + 19.58 kg) having permanent rumen fistula were randomly allotted to three diets in 3x3 Latin

square design. The experimental animals were housed in well ventilated stalls and offered feed 3 times a day to meet nutrient needs as per Kears (1982) requirements. Clean fresh water was made available throughout the experimental period. In each trial the buffaloes were fed the respective diets for 30 days (preliminary period) and then followed by a metabolic trial of 7 days duration. There was a switch over period of 10 days between each trial.

### Rumen studies

At the end of each metabolic trial, rumen liquor was collected for 2 consecutive days, 5 times a day, once before feeding designated as 0 h and then at 2 h intervals after feeding (2, 4, 6 and 8 h) to assess the rumen fermentation pattern. On days of rumen liquor collection, feed was offered at 7 am (before 0 h collection) and at 4 pm (after 8 h collection) to avoid the effect of continuous feeding on concentration of rumen metabolites. The pH of rumen fluid was estimated immediately after collection with help of digital pH meter. The rumen liquor was then strained through four layer muslin cloth. About 5 ml of strained rumen liquor (SRL) of each animal from every collection was preserved by adding 2 drops of saturated solution of mercuric chloride in plastic vials for estimation of total volatile fatty acids (TVFA). The ammonia nitrogen ( $\text{NH}_3\text{-N}$ ) concentration in SRL was estimated immediately after collection. The remaining SRL was deep frozen in plastic vials after adding two drops of 1:4 sulphuric acid for estimation of total nitrogen and other nitrogen (N) fractions.

### Analytical procedure of feeds, faeces and urine

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 the Gallemkemp Automatic Ballistic Bomb Calorimeter. The SRL samples were analysed for total N, TCA-insoluble N (Cline *et al.*, 1958), residual N and food and protozoal N (Singh *et al.*, 1968), ammonia N (Schwartz and Schoeman, 1964) and TVFA (Barnett and Reid, 1956).

### Statistical analysis

The data was subjected to analysis of variance (Snedecor and Cochran, 1980) and the means were tested for significance by Duncan's multiple range test (Duncan, 1955).

## RESULTS AND DISCUSSION

The chemical composition of concentrate mixture, sorghum stover and two expander extruder pelleted complete diets is given in Table 2. The crude protein (CP) content of SFH was about two and a half times higher and the neutral detergent fibre was lower than conventionally used sorghum stover.

The nutrient digestibilities and nutrient balances in buffaloes fed SFH based complete diet is presented in Table 3. The digestibilities of dry matter (DM), organic matter (OM), CP, ether extract (EE) and CF was significantly ( $P < 0.01$ ) higher in the SFH based complete diets compared to the conventional diet, which might be attributed to uniform grinding and blending of concentrate and roughage in the former rather than the separate feeding of the roughage and concentrate in the latter. Further, EEP might have resulted in the binding of fat and protein molecules with each other or with other components of the feed, thus protecting

them from rumen microbes and exposing them for efficient digestion in small intestine (Broderick *et al.*, 1991; Hauck *et al.*, 1994) resulting in higher fat and protein digestibilities. Such beneficial effects on nutrient digestibility with expander-extruder processing of various crop residues based complete diets was reported in Ongole bull calves (Reddy and Reddy, 1999; Reddy *et al.*, 2002), buffalo bulls (Nagalakshmi and Reddy, 2010b) and sheep (Thirumalesh *et al.*, 2003) fed maize cobs, sugarcane bagasse, cotton stalks and bajra straw based complete diets, respectively. Reddy and Reddy (1998) reported higher DM, OM, CP and CF digestibilities in Ongole calves fed EEP processed complete diets containing 28.5% SFH as the sole roughage source compared to a conventional diet (concentrate and chopped sorghum straw). In the present study, among the complete diets the DM, CF and nitrogen free extract (NFE) digestibilities was higher ( $P < 0.01$ ) in the 40% SFH based complete diet compared to the 50% SFH diet, which might be due to the higher SFH proportion or an effect of the higher roughage concentrate ratio in latter complete diet. Gelatinization of starch components of feed and loosening of bonds between lignin and soluble carbohydrates (hemicelluloses, xylose, etc) during expander extruder processing resulted in buffaloes digesting more ( $P < 0.01$ ) energy when fed the SFH based complete diets compared to the conventional diet. Similarly, higher energy digestibility was observed in calves fed EEP processed diet containing cotton stalks compared to a conventional diet (Kirubanath *et al.*, 2003).

No effect on ADF and cellulose digestibility was observed with inclusion of sugarcane bagasse (Reddy *et al.*, 2001), maize cobs (Reddy and Reddy, 2000) or cotton stalks (Nagalakshmi and Reddy, 2010b) at the 40% level in expander extruder processed complete diets. But in the present study,

a higher digestibility of ADF and cellulose was observed when incorporated at the 40 or the 50% levels, which might be due to differences in the variation in ADF and cellulose content in the above crop residues.

All the animals were on positive nitrogen (N) and mineral balances, indicating that these diets could supply these nutrients in the required proportion (Table 3). The N balance was higher ( $P < 0.05$ ) in the 40% SFH diet followed by the 50% SFH diet and was lowest on the conventional diet. Nitrogen retention depends upon factors like N intake and energy availability. Higher dietary energy level and greater protein intake increases the N retention (Baruah, 1983). Higher digestible crude protein (DCP) and DE intakes by the animals fed 40% SFH diet, followed by 50% SFH diet compared to conventional ration resulted in similar trend for N balance. Similar to the present findings, Thirumalesh *et al.* (2003) observed higher N balance in lambs fed a 40% bajra straw based EEP diet compared to a conventional diet. No significant effect on calcium and phosphorous retentions was observed in calves fed a 40% sorghum straw (Reddy and Reddy, 1999a) or a sugarcane bagasse (Reddy *et al.*, 2002) based EEP diets compared to conventional rations. While Kishan Kumar *et al.* (2010) observed higher calcium and phosphorous balances in calves fed a palm press fibre based complete diet compared to a conventional diet. In the present study, no effect of complete diet, expander extruder processing and SFH inclusion was observed on calcium balance, while the phosphorous balance was higher on the 40% SFH diet compared to the conventional diet and the balance in buffaloes fed the 50% SFH diet was intermediate between the other two diets.

The nutritive value of diets and plane of nutrition is presented in Table 3. The DCP, total

digestible nutrients (TDN) and digestible energy (DE) content of the diet was highest ( $P < 0.01$ ) in the 40% SFH containing complete diet compared to the other two diets, which was due to higher nutrient digestibilities and balances recorded when fed this diet (Table 4). The daily DM intake in all the groups met the standard requirements recommended by Kears (1982) for 325 kg body weight (6.0 kg DM) indicating that the diets containing SFH were palatable to buffaloes. The DM intake was lower ( $P < 0.05$ ) when fed the 50% SFH complete diet compared to the conventional diet, while the intake on the 40% SFH diet was comparable (Table 3). The water consumption was higher ( $P < 0.01$ ) in buffaloes fed the 50% SFH diet followed by the 40% SFH diet compared to the conventional diet. Increase of water intake on SFH based diets was reported by previous workers in calves (Reddy and Reddy, 1998) and sheep (Reddy *et al.*, 2004). Nagalakshmi and Reddy (2010a) reported higher water intake in buffaloes fed a sugarcane bagasse based expander extruder processed diet. The higher water intake in the 50% SFH diet than the 40% SFH diet was due to the higher roughage component (60%) in this diet. The TDN intake was comparable among all the groups but the DCP and DE intake per kg  $W^{0.75}$  was higher when fed the 40% SFH diet in comparison to the conventional diet and the 50% SFH based complete diet. The DCP and TDN intake per kg metabolic body weight by all groups of buffaloes was higher than the standard intakes of Kears (1982) (2.54 g DCP, 34.49 g TDN per kg  $W^{0.75}$  for 325 kg body weight for maintenance).

Both the hour of sampling and diet influenced the pH, TVFA and various nitrogen fractions but no significant interaction of these factors was observed on above rumen parameters (Table 5). The pH and TVFA concentration were inversely related to each other, indicating

that the pH of SRL was dictated by the TVFA concentration. The pH concentration was lower ( $P < 0.01$ ) while the TVFA concentration was higher ( $P < 0.01$ ) in the buffaloes fed the complete diets in comparison to those fed the conventional diet. The increased TVFA concentration in the SRL of the complete diet fed animals might be due to increased availability of fermentable energy in the complete diets. Similarly, Nagalakshmi and Reddy (2010b) and Reddy *et al.* (2001) observed higher TVFA concentration in buffalo bulls fed expander extruder processed complete diets containing 40% of either cotton stalks or sugarcane bagasse, respectively. The TVFA concentration in general attained peak 2 h after feeding, reduced ( $P < 0.01$ ) by 4 h after feeding, and gradually fell up to 8 h after feeding. The total nitrogen concentration peaked ( $P < 0.01$ ) at 2 h after feeding in all the groups and the peak was maintained till 6 h of feeding. Similarly, the peak levels for ammonia nitrogen and TCA precipitable nitrogen was observed 2 h after feeding and the levels were maintained even up to 8 h after feeding. The peak of total nitrogen, ammonia nitrogen and TCA precipitable N observed at 2 h post feeding might be due to active degradation of protein and hydrolysis of non protein nitrogen substances for microbial protein synthesis. The higher N intake by buffaloes fed the 40% SFH based complete diet could have resulted in a higher ammonia nitrogen concentration in the SRL. The higher TCA precipitable nitrogen concentration observed in the complete diets containing either 40 or 50% SFH might be due to efficient utilization of  $NH_3$  by rumen microbes with simultaneous availability of carbohydrates and higher organic matter digestibility (Table 3). The residual-N in SRL gradually increased and peaked at 4 h post feeding when SFH complete diets were fed while the animals fed conventional diets, the peak

Table 1. Ingredient composition (kg/100kg) of SFH based complete diets.

<b>Ingredient</b>	<b>Concentrate mixture</b>	<b>EEP- 40% SFH</b>	<b>EEP- 50% SFH</b>
Sunflower heads	--	40.0	50.0
Sorghum straw	--	--	10.0
Maize	30.0	20.0	10.0
Groundnut cake	16.0	9.0	15.0
Cottonseed cake	11.0	6.0	5.0
Wheat bran	--	6.5	--
Deoiled rice bran	39.0	5.0	--
Molasses	--	10.0	7.0
Urea	1.0	0.5	--
Salt	1.0	1.0	1.0
Mineral mixture	2.0	2.0	2.0
Vitamin mixture (g/qt)	20.0	10.0	10.0

Table 2. Chemical composition (% DM basis) of experimental diets.

<b>Constituent</b>	<b>Concentrate mixture</b>	<b>EEP- 40% SFH</b>	<b>EEP- 50% SFH</b>	<b>Sorghum stover</b>	<b>Sunflower heads</b>
Organic matter	85.02	85.92	84.07	87.83	84.56
Crude protein	18.16	13.82	13.29	2.45	7.82
Ether extract	2.38	2.10	2.45	1.30	2.86
Crude fibre	31.04	29.09	32.37	34.45	34.34
Nitrogen free extract	33.44	40.91	35.97	49.64	39.37
Neutral detergent fibre	70.87	57.27	56.10	75.57	55.66
Acid detergent fibre	50.33	38.84	45.73	71.01	46.27
Hemicellulose	20.54	18.43	10.37	5.23	16.10
Cellulose	30.42	27.93	31.53	57.64	30.17
Calcium	2.45	2.16	1.67	1.31	2.51
Phosphorus	0.73	0.73	0.72	0.72	0.45

Table 3. Nutrient digestibility (%) and balances (g) in buffaloes fed SFH based complete diets.

Nutrient	Conventional diet	EEP-40% SFH	EEP- 50% SFH	SEM
Nutrient digestibility				
Dry matter	50.66 <sup>c</sup>	67.00 <sup>a</sup>	59.80 <sup>b</sup>	2.385**
Organic matter	54.34 <sup>b</sup>	69.64 <sup>a</sup>	62.30 <sup>a</sup>	2.336**
Crude protein	47.88 <sup>b</sup>	62.23 <sup>a</sup>	50.07 <sup>a</sup>	2.333**
Ether extract	50.62 <sup>b</sup>	64.18 <sup>a</sup>	63.17 <sup>a</sup>	2.414**
Crude fibre	31.68 <sup>c</sup>	61.65 <sup>a</sup>	55.06 <sup>b</sup>	4.592**
Nitrogen free extract	76.26 <sup>ab</sup>	80.36 <sup>a</sup>	70.98 <sup>b</sup>	1.475**
Cell contents	64.56	71.43	66.21	1.312
Neutral detergent fibre	46.29 <sup>b</sup>	63.22 <sup>a</sup>	54.89 <sup>ab</sup>	2.814*
Acid detergent fibre	43.73 <sup>b</sup>	53.25 <sup>a</sup>	52.75 <sup>a</sup>	1.573**
Hemicellulose	61.53 <sup>b</sup>	79.89 <sup>a</sup>	67.30 <sup>ab</sup>	3.306*
Cellulose	51.40 <sup>b</sup>	63.80 <sup>a</sup>	59.20 <sup>a</sup>	2.136*
Energy	46.82 <sup>b</sup>	66.78 <sup>a</sup>	55.42 <sup>ab</sup>	3.128**
Nutrient balance				
Calcium	77.45	85.02	90.35	2.682
Phosphorus	11.23 <sup>b</sup>	20.97 <sup>a</sup>	16.25 <sup>ab</sup>	1.529**
Nitrogen	25.62 <sup>b</sup>	46.74 <sup>a</sup>	36.34 <sup>ab</sup>	3.640*

<sup>abc</sup>Means with different superscripts in a row differ significantly: \*P<0.05; \*\*P<0.01.

Table 4. Nutritive value and plane of nutrition of buffaloes fed sunflower heads based diets.

Nutrient	Conventional diet	EEP-40% SFH	EEP- 50% SFH	SEM
Nutritive value				
Crude protein %	8.87 <sup>c</sup>	13.80 <sup>a</sup>	12.42 <sup>b</sup>	0.744
Digestible crude protein %	4.35 <sup>c</sup>	10.03 <sup>a</sup>	7.08 <sup>b</sup>	0.841
Total digestible nutrients %	51.41 <sup>b</sup>	63.69 <sup>a</sup>	56.04 <sup>b</sup>	1.863
DE (Mcal/kg)	2.53 <sup>b</sup>	4.36 <sup>a</sup>	2.86 <sup>b</sup>	0.318
Nutrient intake				
DMI/kgW <sup>0.75</sup> (g/d)	83.61 <sup>a</sup>	77.50 <sup>ab</sup>	71.30 <sup>b</sup>	2.172*
DCP intake/kg W <sup>0.75</sup> (g/d)	3.70 <sup>b</sup>	7.80 <sup>a</sup>	5.05 <sup>b</sup>	0.621**
TDN intake W <sup>0.75</sup> (kcal/d)	43.92	49.85	40.00	2.215
DE intake/kg W <sup>0.75</sup> (kcal/d)	216.9 <sup>b</sup>	342.6 <sup>a</sup>	204.4 <sup>b</sup>	26.96*
Water intake/kg DMI (L)	4.40 <sup>b</sup>	5.96 <sup>ab</sup>	6.83 <sup>a</sup>	0.392**

<sup>abc</sup>Means with different superscripts in a row differ significantly: \*P<0.05; \*\*P<0.01.

Table 5. Rumen fermentation pattern in buffaloes fed sunflower heads based complete diets.

	pH	TVFA (meq/ dl)	NH <sub>3</sub> -N (mg/dl)	Total-N (mg/dl)	TCA-ppt-N (mg/dl)	Residual N (mg/dl)
Diet						
Conventional diet	7.07 <sup>a</sup>	60.34 <sup>b</sup>	12.52 <sup>b</sup>	84.70 <sup>b</sup>	25.75 <sup>b</sup>	35.63
EEP-40% SFH	6.29 <sup>b</sup>	79.07 <sup>a</sup>	18.88 <sup>a</sup>	111.93 <sup>a</sup>	34.92 <sup>ab</sup>	43.37
EEP-50% SFH	6.47 <sup>b</sup>	83.80 <sup>a</sup>	13.58 <sup>b</sup>	115.6 <sup>a</sup>	42.93 <sup>a</sup>	39.24
	**	**	**	**	**	NS
Period						
0 h	6.68 <sup>a</sup>	68.00 <sup>bc</sup>	9.62 <sup>b</sup>	77.28 <sup>c</sup>	24.81 <sup>b</sup>	31.01 <sup>c</sup>
2 h	6.56 <sup>bc</sup>	90.81 <sup>a</sup>	20.00 <sup>a</sup>	125.56 <sup>a</sup>	44.03 <sup>a</sup>	45.16 <sup>ab</sup>
4 h	6.44 <sup>c</sup>	78.43 <sup>b</sup>	17.31 <sup>a</sup>	118.78 <sup>ab</sup>	42.17 <sup>ab</sup>	46.25 <sup>a</sup>
6 h	6.42 <sup>c</sup>	71.95 <sup>bc</sup>	14.39 <sup>ab</sup>	109.47 <sup>abc</sup>	34.19 <sup>ab</sup>	40.65 <sup>abc</sup>
8 h	6.75 <sup>ab</sup>	62.82 <sup>c</sup>	13.65 <sup>ab</sup>	89.31 <sup>bc</sup>	27.47 <sup>ab</sup>	33.99 <sup>bc</sup>
	**	**	**	**	*	*
SEM	0.050	1.958	0.893	4.386	2.217	1.841

<sup>abc</sup>Means with different superscripts in a sub-column differ significantly: \*P<0.05; \*\*P<0.01; SEM: Standard error mean.

level was observed at 2 h and thereafter the levels fell drastically. Expander-extruder processing of complete diets containing various crop residues as the sole roughage source, viz., maize cobs (Reddy and Reddy, 2000), sugarcane bagasse (Reddy *et al.*, 2001), cotton stalks (Nagalakshmi and Reddy, 2010) increased the concentration of total nitrogen and TCA precipitable nitrogen in rumen liquor of buffalo bulls compared to conventional diets.

The results of this study indicated that sunflower heads can form a roughage source for ruminants by incorporating at 40-50% level. Out of these two complete diets, the expander extruder processed complete diet containing 40% SFH proved better in terms of nutrient utilization and rumen fermentation pattern.

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