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Evaluation of crop residue based complete rations through *in vitro* digestibility

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ABSTRACT

The present investigation was carried out to evaluate three potential complete rations made from locally available ingredients through *in vitro* digestibility (DM, CP, NDF and ADF) and *in vitro* total volatile fatty acids (TVFA) production. Three iso-nitrogenous complete rations comprising of maize stover (T_1), red gram straw (T_2) or black gram straw (T_3) and concentrate in 60:40 ratio were prepared and the cost/kg diets were 5.2, 5.5 and 5.7 rupees/Kg diet, respectively. Three fistulated buffalo bulls (5 yrs, 350 ± 9.36 kg BW) used as donors of rumen inoculums were fed the same three complete rations (T_1, T_2 and T_3) after proper adaptation. The three complete rations were iso-nitrogenous with CP content ranging from 12.62 to 12.82, while T_3 contained higher EE (1.68 %) and TA (9.75 %) and higher NFE (34.38 %) in T_1 than in other complete rations. However, variation was apparent in the fiber fractions of the three complete rations attributable to varying sources of the fibrous crop residues. Overall *in vitro* DM digestibility (IVDMD) and *in vitro* NDF digestibility (IVNDFD) % was higher (p<0.05) in T_1 (58.59 ± 1.55 and 56.33 ± 0.24) followed by T_3 (57.75 ± 0.46 and 54.20 ± 0.64) and in T_2 (55.45 ± 0.69 and 53.23 ± 1.25). However, the differences for *in vitro* CP digestibility (IVCPD) and *in vitro* ADF digestibility (IVADFD) % were higher in T_1 than in other complete rations, the values did not differ statistically. Overall TVFA (meq/L) production was higher in T_1 (87.65 ± 7.17) than in T_2 (83.00 ± 5.74) and T_3 (84.00 ± 5.52). It is concluded that T_1 is superior to T_2 or T_3 in terms of *in vitro* digestibility (DM, CP, NDF and ADF), *in vitro* TVFA production and cost of formulation.

Keywords

Complete rations, *In vitro* digestibility, *In vitro* TVFA production

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INTRODUCTION

The huge livestock population of India needs to be fed with balanced rations in order to maintain productivity potentials (Waje et al., 2010). The scarcity of green fodder and escalating demand of concentrate ingredients for human consumption has led to the utilization of non-competitive and non-conventional crop residues in livestock feeding. Use of locally available feed ingredients can substantially reduce the cost of production of livestock (Saha et al., 2002). In the recent years, the concept of feeding complete rations comprising of fibrous crop residues to dairy animals became popular among the farmers. The objective of complete rations is to provide a blend of all the feed ingredients including roughages without giving any choice to the animal for selection of specific ingredient (Khan et al., 2010). The merits of complete rations are related to a stable environment for rumen fermentation, minimal fermentation losses and fluctuation in release of ammonia and enhancement in utilization of low grade roughages (Venkanna et al., 1997). Besides these complete rations facilitates control ratio of roughage to concentrate, provides uniform feed intake, reduces feed wastage, enhances nitrogen balance and milk production and reduces the cost of

feeding (Raut et al., 2002; Hundal et al., 2004; Lailer et al., 2010). Hence, the present investigation was undertaken to evaluate some potential complete rations made from locally available crop residues through *in vitro* digestibility.

MATERIALS AND METHODS

Selection and management of bulls: Three fistulated buffalo bulls were used as donors of rumen inoculums. The dietary requirements of the donor animals were met by feeding three separate complete rations (T_1, T_2 and T_3), which were prepared using maize stover, red gram straw and black gram straw and concentrate mixture in 60: 40 ratio, respectively, as per ICAR (1998). Clean, fresh drinking water was offered *ad libitum* daily to the donor animals. The ingredient composition of the experimental complete rations is provided in **Table 1**. Representative samples of the rations were analyzed for proximate constituents (AOAC, 2007) and forage fiber constituents (Van Soest et al., 1991). Each of the complete rations (T_1, T_2 and T_3) was formulated to have 12.77 and 57.05; 12.62 and 54.39; 12.82 and 54.09 per cent CP and TDN, respectively. However, the cost/kg diet for T_1, T_2 and T_3 worked out to be 5.2, 5.5 and 5.7 rupees/Kg diet, respectively.

Table 1: Ingredient composition of crop residue based complete rations.

Ingredient	T_1	T_2	T_3
Roughage (Kg)			
Maize stover	60	-	-
Red gram straw	-	60	-
Black gram straw	-	-	60
Concentrate (Kg)			
Maize grain	5.5	6.5	8.5
DORB	5.5	6.5	7.5
Cotton seed cake	11.0	12.0	11.5
Gingelly cake	16.0	13.0	10.5
Mineral mixture	1.5	1.5	1.5
Salt	0.5	0.5	0.5
Overall CP (%)	12.77	12.62	12.82
Cost (rupees/kg diet)	5.2	5.5	5.7

***In vitro* studies:** Dried and ground (0.5 mm particle size) components of each ration were mixed thoroughly in required proportions and used as substrate for two stage *in vitro* method (Tilley and Terry, 1963). Following 21 days of feeding the same three complet rations rumen liquor was collected from respective donors 4 h after feeding and strained through three layers of muslin cloth. Incubations were carried out with 40 ml McDougall's saliva (McDougall, 1948), 10 ml of strained rumen liquor (SRL) and 0.5 g substrate for each of three replicates for 48 h incubation with occassional shaking at 39 ± 2^{0}C. Anaerobic conditions were created in the sytem by bubbling CO_2 gas and maintaining pH to 6.8. After 48 h of incubation with occassional shaking at 39 ± 2^{0}C under anaerobic condition, microbial activity of the samples was stopped by adding 2 ml of 6 N HCl and 0.1 g pepsin (1:3000) powder. Incubate the samples for another 24 h and filter the contents through Whatman filter paper (No. 54). The residue is dried at 100 ^{o}C overnight and used for estimation of % IVDMD. Similarly, dried residue of other sets of samples was used for the estimation of % IVCPD, % IVNDFD and % IVADFD by estimating CP, NDF and ADF by standard procedures.

TVFA estimation: Separate samples were incubated for 0, 2, 4, 6 and 8 h with occassional shaking at 39 ± 2^{0}C under anaerobic condition for estimation of TVFA. After centrifuging the samples at 1500 rpm for 10 min, the supernatents were collected for the estimation of TVFA (Barnett and Reid, 1957).

Statistical analysis: The entire experiment was conducted using completely randomized design and the data were statistically analyzed as per Snedecor and Cochran (1989) using Compare Means (SPSS, 2008).

RESULTS AND DISCUSSION

Chemical composition of complete rations: The roughage: concentrate ratio in the three complete rations (T_1 to T_3) was 60: 40 ratio. Similar roughage: concentrate ratio has been used by earlier workers (Kaur et al., 2004; Nagalakshmi et al., 2005; Saijpaul et al., 2005; Das et al., 2008). The three complete rations were iso-nitrogenous with CP ranging from 12.62 to 12.82% and higher EE (1.68 %) and TA (9.75 %) content in T_3 than in other complete rations (**Table 2**). The % NFE content was higher in T_1 (34.38) followed by T_3 (30.23) and T_2 (26.84). The differences were pertinent in the fiber fractions of the three complete rations. The per cent NDF, ADF and cellulose were higher in T_2 (66.17, 44.29 and 32.83), respectively, followed by T_3 (55.37, 37.94 and 25.22) and T_1 (58.86, 33.73 and 24.70). But the % ADL was higher in T_2 than in T_3 and T_1. This indicates T_1 is less fibrous containing more of soluble sugars than in other complete rations under study. These results corroborated with the findings of Venkateswarlu et al. (2013). The different proximate and cell wall constituents (% DM) of the crop residue based complete rations under study were within the

range of the values reported for different crop residue based complete rations by various authors (Prakash et al., 2004; Afzal et al., 2008; Sihag et al., 2008; Dhuria et al., 2009). Further, the cost/kg diets (**Table 1**) were 5.2, 5.5 and 5.7 rupees/kg diet, respectively, for T_1, T_2 and T_3.

Table 2: Chemical composition (%DM basis) of crop residue based complete rations.

Parameter	T_1	T_2	T_3
Organic matter	90.80	93.88	90.25
Total ash	9.20	6.12	9.75
Crude protein	12.77	12.62	12.82
Ether extract	1.20	1.41	1.68
Crude fiber	42.45	53.01	45.52
Nitrogen free extract	34.38	26.84	30.23
Neutral detergent fiber	58.86	66.17	55.37
Acid detergent fiber	33.73	44.29	37.94
Hemi-cellulose	25.13	21.88	17.43
Cellulose	24.70	32.83	25.22
Acid detergent lignin	8.38	12.34	11.50

Table 3: *In vitro* digestibility (%) of DM, CP, NDF and ADF of crop residue based complete rations.

Nutrient digestibility (%)	Treatments			
	T_1	T_2	T_3	SE*
IVDMD*	58.59[a]	55.45[c]	57.75[b]	0.94
IVCPD	62.22	61.40	59.65	0.76
IVNDFD*	56.33[a]	53.23[c]	54.20[b]	0.92
IVADFD	44.73	42.10	43.19	0.76

Values are means of triplicate samples; SE*: standard error
Means within the same row with different superscripts (a-c) differ significantly (p<0.05).

Table 4: TVFA concentration (meq/L of SRL) of crop residue based complete rations after different hours of incubation.

Hours	T_1	T_2	T_3	SE**
0	69.00[a]	67.50[b]	69.25[a]	3.79
2	91.50[a]	90.50[b]	89.75[b]	1.62
4	111.75[a]	100.25[b]	101.25[b]	2.68
6	87.50[a]	81.75[c]	83.50[b]	1.21
8	78.50[a]	75.00[b]	76.25[b]	0.72
Mean	87.65[a]	83.00[b]	84.00[b]	
SE**	7.17	5.74	5.52	

Values are means of triplicate samples
Mean (n=15); SE**: standard error
Means within the same row with different superscripts (a-c) differ significantly (p<0.01).

***In vitro* analysis of complete rations**: The *in vitro* digestibility (%) of DM, CP, NDF and ADF of the three crop residue based complete rations was presented in **Table 3**. Data revealed that overall IVDMD and *in* IVNDFD % was higher (P<0.05) in T_1 (58.59 ± 1.55 and 56.33 ± 0.24) followed by T_3 (57.75 ± 0.46 and 54.20 ± 0.64) and in T_2 (55.45 ± 0.69 and 53.23 ± 1.25) in SRL of buffalo bulls. The values in the present study corroborated with the findings of Hozhabri and Singhal (2006) in sugar cane bagasse based complete diets, Shojaeian and Thakur (2007) and Thakur et al. (2008) in wheat straw based complete diets). Increased IVDMD % might be due to presence of more soluble carbohydrates in the form of starch (Sardar et al., 1996, 1997). Also, the increase in DM digestibility appeared to be associated with higher NDF digestibility which confirms the previous reports (Wang et al., 2004; Shojaeian and Thakur, 2007). Further, increased NDF digestibility enhances the energy density of the diets and stimulated microbial N production (Oba and Allen, 2000). However, IVCPD and IVADFD % were comparable among the different crop residue based complete rations under study. The values observed for the *in vitro* CP digestibility in the present study were in agreement with the values reported (Dutta et al., 2007) in arhar straw based complete diets. The values observed for the *in vitro* ADF digestibility of the present study were higher compared to the values given by Girdhar and Balaraman (2005) in berseem based total mixed rations.

TVFA estimation in complete rations: The data on TVFA (meq/L) production of the three complete rations was presented in **Table 4**. Overall TVFA (meq/L) production was higher in T_1 (87.65 ± 7.17) than in T_3 (84.00 ± 5.52) and T_2 (83.00 ± 5.74). The peak concentration of TVFA was higher (P<0.01) between 2 to 4 h post feeding which might be due to higher ruminal microbial activity, hydrolysis of protein and NPN (Tomar and Sengar, 1999; Samanta et al., 2006; Venkanna et al., 1997). *In vitro* TVFA production is an indicator of carbohydrate digestion especially the crude fiber (Girdhar and Balaraman, 2005) which reflected in better NDF digestibility in T_1 ration. The increased TVFA production in T_1 could be because of the fact that due to presence of more soluble sugars which induced the microbial activity resulting in increased microbial fermentation.

CONCLUSION

The ration T_1 is superior to T_2 and T_3 in terms of *in vitro* digestibility (DM, CP, NDF and ADF), *in vitro* TVFA production, and cost of formulation. The use of maize stover based complete ration made from locally available ingredients may maximize and economize the production of livestock through improved

degradability and utilization of nutrients, and may be assessed through feeding trials in animals.

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