Full Length

IN VITRO EVALUATION OF SUGARCANE TOPS BASED COMPLETE FEED

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ABSTRACT

The present research work was carried out to evaluate the effect of inclusion of different levels of sugarcane tops and different levels of crude protein in the complete feed on in vitro parameters. Three complete feeds were prepared with three different crude protein levels of 8%, 10% and 12% utilizing sorghum stover as a roughage source. Twelve sugarcane tops based complete feeds were prepared by replacing sorghum stover with sugarcane tops at four different levels of 25%, 50%, 75% and 100%, with three different crude protein levels (8%, 10% and 12%) in each level of inclusion. Total digestible nutrients of 50% and roughage:concentrate ratio of 65:35 have been maintained in all the fifteen complete feeds (CFE 1 to CFE 15). There was a significant difference (P<0.01) in organic matter, crude fibre, total ash, acid insoluble ash, neutral detergent fibre, acid detergent fibre, acid detergent lignin, cellulose and hemicellulose contents (%) among complete feeds. In vitro gas production (ml/48 hours/200mg) and in vitro dry matter degradability (%) of complete feeds did not differ significantly (P>0.05) among complete feeds. In vitro organic matter degradability (%) was significantly higher (P<0.05) at 75% and 100% replacement of sorghum stover with sugarcane tops. Based on the results of the experiment, it can be concluded that different levels of crude protein in the compete diets did not have any effect on the in vitro parameters except in vitro organic matter degradability, which was significantly higher (P<0.05) at 75% (CFE 10, 11 and 12) and 100% (CFE 13, 14 and 15) replacement of sorghum stover with sugarcane tops.

Key words: Sorghum stover, Sugarcane tops, Complete feed, *In vitro* dry matter degradability

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INTRODUCTION

India possesses one of the largest livestock populations in the world, yet the productivity per animal remains low compared to global standards. One of

the several challenges faced by animal husbandry sector is inadequate feed and fodder resources. There is net deficiency of 35.6% green fodder, 10.95% dry fodder and 44% concentrate feed materials in the country (Vision, IGFRI, 2050). Crop residues can be utilized as an alternative source of feed for ruminants. The Indian ministry of new and renewable energy estimates that India produces on an average 500 million tonnes (MT) of crop residue annually. The crop residue generated in Tamil Nadu is about 11.69 MT/year, 0.78 MT/year, 1.56 MT/ year, 12.37 MT/year from cereal crops, fiber crops, oilseed crops, sugarcane, respectively (Meena *et al.*, 2022). Sugarcane tops is one of the by-products of sugarcane harvesting and it includes the green leaves on top, leaf bundle sheaths and some immature cane. Sugarcane leaves are rich in crude fibre content and soluble carbohydrates. Sugarcane tops are potential source of feed for livestock, but it should be supplemented with protein rich feeds (Tolera, 2007). Hence, sugarcane tops can be utilised as roughage source in ruminant feeding. The results of in vitro gas production technique for measuring dry matter digestibility and gas production closely match with in vivo investigations (Menke *et al.,* 1979). Hence, in vitro evaluation serves as a rapid and more affordable substitute for in vivo digestibility trials, which can be used to find the inclusion level of sugarcane tops in the complete feed.

MATERIALS AND METHODS

Concentrate feed ingredients (maize, de-oiled rice bran and de- oiled ground nut cake) and sorghum stover were collected from feed mill and fodder unit of Veterinary College and Research Institute, Orathanadu, respectively. Sugarcane tops were collected from a local farmer's field in Vettikadu village, Orathanadu and all feed samples were dried and passed through 1mm sieve and stored in air tight bags for complete feed preparation and further analysis. Three sorghum stover based complete feeds were prepared with three different crude protein (CP) levels of 8%, 10% and 12%. Twelve sugarcane tops based complete feeds were prepared by replacing sorghum stover with sugarcane tops at four different levels of 25%, 50%, 75% and 100%, with three different crude protein levels (8%, 10% and 12%) in each level of inclusion. The ingredient composition of fifteen complete feeds are given in Table 1. Total digestible nutrients (TDN) value of 50% and roughage to concentrate (R:C) ratio of 65:35 have been maintained in all the fifteen different complete feed formulations.

The ground roughage samples and complete feeds were analyzed for proximate principles as per the methods described in AOAC (1999). Feed samples were analyzed for different fibre fractions as per the methods of Van Soest *et al*. (1991). For the in vitro gas production studies, separate trials were conducted to estimate the various parameters such as total gas production, in vitro dry matter and in vitro organic matter degradability. The incubation of each ingredient was carried out in 100 ml calibrated glass syringes as described by Menke *et al*. (1979). The substrate (200 mg) was weighed on a plastic boat with removable stem and placed into the bottom of the glass syringe without touching the

sides of syringe. The piston was lubricated with petroleum jelly and pushed into the barrel of glass syringe. Each sample with respective blank was taken in triplicate.

Rumen liquor was collected from sheep fed with sorghum stover as basal roughage and rumen inoculum was prepared as per the procedure mentioned by Menke *et al.* (1979) and 30 ml of rumen inoculum was added into each syringe. The syringes were then kept in an incubator at 39 ± 0.5°C up to the incubation period. The level of piston was recorded and the syringes were placed in an automatic water bath shaker with set temperature of 39 ± 0.5°C. The syringes were shaken every two hours up to 48 hours of incubation. Gas production (ml/200 mg substrate) during fermentation was measured after 48 hours. For the determination of apparent dry matter and organic matter degradability, the contents of each syringe were transferred quantitatively into sintered glass crucible (porosity G-3) and filtered by using vaccum pump and dried in the hot air oven till constant weight. The dry weight of residue was calculated. Dry weight of blank was subtracted from those recorded for the test samples. The residue in each crucible was ashed in muffle furnace at 550°C for 2 hours to determine the organic matter (OM) content.

As per the method of the statistical analysis system (SPSS, version 20.04 windows), the data collected during in vitro trial were aggregated and subjected to both one-way and two-way ANOVA and means were compared, and significance was determined based on suitability at $P<0.05$ and $P<0.01$.

RESULTS AND DISCUSSION

Chemical composition of sorghum stover and sugarcane tops.

The chemical composition of sorghum stover and sugarcane tops are given in the Table 2. The crude protein (% CP) content of sorghum stover and sugarcane tops were 3.83 and 4.79, respectively, which was in agreement with 4.01% CP as stated by Babu *et al.* (2014) in sorghum stover and comparable with value of 4.98% as reported by Pal *et al.* (2022) in sugarcane tops. Crude fibre (CF%) content of sorghum stover was 32.97 lower than the value of 38.60% as reported by Babu *et al.* (2014). Crude fibre % of sugarcane tops was 34.98, much lower than the value (42.22%) reported by Rakhmani and Puastuti (2024). Neutral detergent fibre (NDF %) content of sorghum stover was 67.02 and it was in accordance with the NDF value of 67.40 as reported by Elseed *et al.* (2007). Neutral detergent fibre value of sugarcane tops was 75.33, which was higher than the values of 71.71 as reported by Kebede *et al.* (2020). Acid detergent fibre (ADF) (%) content of sorghum stover was 43.52, which was corroborated with the value (43.54) reported by Babu *et al.* (2014). Acid detergent fibre (ADF) (%) content of sugarcane tops was 46.09. In contrast, Adelusi and Ojo (2018) reported 42.60, which was lower than ADF content arrived in the present study. Acid detergent lignin (ADL) (%) content of sorghum stover was 5.64, which was much lower than 8.53 as reported by Pailan *et al.* (2008). Acid detergent lignin (ADL) (%) content of sugarcane tops was 4.80 and it

was comparable with ADL content of 5.00 as reported by Pal *et al.* (2022).

Proximate composition of complete feeds

The proximate compositions of different complete feeds are given in the Table 3. Organic matter (OM) (%) content of complete feeds ranged from 87.79 to 88.42 and these findings were similar to the value (87.10) reported by Jaishankar et al. (2021) in sugarcane trash based complete feed with R:C ratio 80:20, but contrary to value (90.80) reported by Konka *et al.* (2015) in maize stover based complete feed with R:C ratio of 60:40. The OM% content of complete feeds decreased significantly ($P<0.01$) when the level of inclusion of sugarcane tops increased and this was due to lower OM content of sugarcane tops than the sorghum stover, in the present study. Crude protein (CP) (%) content of complete feeds were in three levels, such as 8%, 10% and 12% as they were actually formulated to contain the same in the study. Similar CP (%) contents of 12.1 (Devasena and Prasad, 2014), 7.85 (Venkateswarlu *et al.*, 2014) and 9.41 (Jaishankar *et al.*, 2021) were reported in various complete feeds. Crude fibre (CF) (%) content of complete feeds ranged between 20.16 and 23.52, which increased significantly among complete feeds ($P<0.01$) when level of inclusion of sugarcane tops was increased. This was due to higher CF content of sugarcane tops than sorghum stover utilized in the current study. Reddy *et al.* (2012) reported complete feeds with 60% roughage, contained CF in the range of 21.34 to 26.52 which was in accordance with values arrived in the present study.

Fibre fractions of complete feeds

The result of fibre fraction of different complete feeds are given in Table 4. Neutral detergent fibre (NDF) (%) of complete feeds ranged between 55.37 and 64.7. It was supported by the findings of Hozhabri and Singhal (2006), who reported NDF content of 58.64, in complete feed with R:C ratio of 60:40. Acid detergent fibre (ADF) (%) content of complete feeds varied between 30.57 and 35.54, which corroborated with 34.87 in complete feed with R:C ratio of 60:40 as disclosed by Hozhabri and Singhal (2006)

Acid detergent lignin (ADL) (%) content of complete feeds were in the range of 4.82 to 5.56, which was lower than ADL value (6.42) reported by Venkateswarlu *et al.* (2014) in complete feed with 70R:30C. This may be because of lower ADL content in the ingredients used in the present study.

In vitro gas production, dry matter degradability and organic matter degradability of complete feeds

The results of in vitro evaluation of complete feeds are given in the Table 5. In vitro gas production (IVGP) (ml/48 hours/200mg substrate) of complete feeds varied between 29.12 and 35.67 and there was no significant difference ($P>0.05$) among the complete feeds. Gudepu *et al.* (2025) stated IVGP (ml/48 hours/200 mg) value of sorghum stover and maize grain based complete feed with 50R:50C ratio was 36.15, which was greater than the IVGP value of present study and could be due to higher

level of inclusion of concentrate. Halburge (2019), reported net gas production (ml/48 hours/gm DM) of 138.58 in berseem green fodder based complete feed with 65R:35C ratio, that implies gas production of 27.72 ml/48 hours/200mg which was lower than the IVGP value obtained in the present study.

In vitro dry matter degradability (% IVDMD) of complete feeds were in the range of 47.79 to 51.16 and there was no significant difference (P>0.05) among complete feeds. These findings aligns with the results of Hozhabri and Singhal (2006), who reported IVDMD (%) of 50.22 in sugarcane bagasse based complete feed with 60R:40C ratio. But, Konka *et al.* (2015) reported slightly higher IVDMD of 58.59% in maize stover based complete feeds with 60R:40C ratio.

In vitro organic matter degradability (IVOMD %) of complete feeds varied between 58.07 and 63.93 which differed significantly (P<0.05) among complete feeds. These results were corroborated with the IVOMD (%) value of 60.98 arrived by Hozhabri and Singhal (2006) in sugarcane bagasse based complete feed with 60R:40C ratio. In contrast, Vinod Kumar (2013) stated lesser IVOMD (%) values of 50.47, 51.93 and 54.26 in groundnut haulms based complete feed with 60R:40C ratio.

The result of two-way ANOVA is given in Table 6. Level of inclusion of sugarcane tops and CP level has not affected the IVGP and IVDMD, which was supported by Van Dung *et al*. (2014), who stated that increasing the CP level of concentrate had no effect on the IVDMD and IVOMD. Suriyapha *et al.* (2025) reported that CP level had no effect on cumulative gas production and gas kinetics, as gas production from protein fermentation was not more considerable, which was also in line with the results obtained in the present study. In vitro organic matter degradability was affected by the main effect of level of inclusion of sugarcane tops (P = 0.000). In vitro organic matter degradability values at different level of inclusion of sugarcane tops were given in Table 7. In vitro organic matter degradability values at 75% (CFE10, CFE 11 and CFE 12) and 100% (CFE 13, CFE 14 and CFE 15) inclusion level of sugarcane tops were significantly (P<0.05) higher than IVOMD values at 0%, 25% and 50% inclusion level of sugarcane tops. This may be due to low ADL content of complete feeds at 75% and 100% inclusion level of sugarcane tops as ADL in sugarcane tops was significantly lower (P<0.01) than sorghum stover in the current study.

CONCLUSION

It can be concluded that, in vitro gas production and in vitro dry matter degradability of complete feeds did not differ significantly among complete feeds, however, in vitro organic matter degradability was significantly higher (P<0.05) at 75% and 100% level of inclusion of sugarcane tops. Different levels of crude protein in the complete diets did not have any effect on the in vitro parameters.

Table.1. Ingredient composition of sorghum stover based complete feeds (CFE1 to CFE3) and sugarcane tops based complete feeds (CFE4 to CFE15).

Level of inclusion of Sugarcane tops	0% (sorghum stover based)			25%			50%			75%			100%		
Crude protein	**8%**	**10%**	**12%**	**8%**	**10%**	**12%**	**8%**	**10%**	**12%**	**8%**	**10%**	**12%**	**8%**	**10%**	**12%**
Ingredients (%)	**CFE 1**	**CFE 2**	**CFE 3**	**CFE 4**	**CFE 5**	**CFE 6**	**CFE 7**	**CFE 8**	**CFE 9**	**CFE 10**	**CFE11**	**CFE12**	**CFE13**	**CFE14**	**CFE15**
Sorghum stover	65	65	65	49	49	49	32.5	32.5	32.5	16	16	16	0	0	0
Sugarcane tops	0	0	0	16	16	16	32.5	32.5	32.5	49	49	49	65	65	65
Maize grain	0	0	0	0	0	0	0	0	0	2	0.5	0	5	1.5	0
De-oiled ground nut cake	4	11.5	19	3.5	11	18.5	2.5	10	18	2.5	9.5	17.5	2.5	9.5	16.5
De-oiled rice bran	28	20.5	13	28.5	21	13.5	29.5	22	14	27.5	22	14.5	24.5	21	15.5
Mineral mixture	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Salt	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table.2. Chemical composition (% on DMB) of sorghum stover and sugarcane tops (Mean* ±S.E)

Nutrients	Sugarcane tops	Sorghum stover	P value
Proximate composition (%)			
Dry matter (DM)	35.41 ± 0.50a	90.92 ± 0.11b	0.000
Organic matter (OM)	91.81 ± 0.05	91.91 ± 0.28	0.732
Crude protein (CP)	4.79 ± 0.07b	3.83 ± 0.14a	0.004
Ether extract (EE)	3.04 ± 0.13	3.05 ± 0.29	0.970
Crude fibre (CF)	34.98 ± 0.12b	32.97 ± 0.32a	0.004
Nitrogen free extract (NFE)	48.98 ± 0.28a	52.04 ± 0.42b	0.004
Total ash (TA)	8.19 ± 0.05	8.08 ± 0.27	0.736
Acid insoluble ash (AIA)	3.09 ± 0.02b	2.40 ± 0.00a	0.000
Fibre fractions (%)			
Neutral detergent fibre (NDF)	75.33 ± 0.40b	67.02 ± 0.44a	0.000
Acid detergent fibre (ADF)	46.09 ± 0.26b	43.52 ± 0.14a	0.001
Acid detergent lignin (ADL)	4.80 ± 0.10a	5.64 ± 0.05b	0.002

(*n=3), ^{a,b} Values with different superscripts in a row differ significantly ($P<0.05$)

Table.3. Proximate composition of (% on DMB) of complete feeds (Mean* ±S.E)

Nutrients	CFE 1	CFE 2	CFE 3	CFE 4	CFE 5	CFE 6	CFE 7	CFE 8	CFE 9	CFE 10	CFE11	CFE12	CFE13	CFE14	CFE15	P value
DM	92.62 ± 0.08	92.55 ± 0.1	92.49 ± 0.05	92.67 ± 0.21	92.30 ± 0.14	92.58 ± 0.09	92.31 ± 0.22	92.36 ± 0.13	92.65 ± 0.25	92.85 ± 0.14	92.21 ± 0.16	92.63 ± 0.12	93.59 ± 0.05	94.00 ± 0.06	93.64 ± 0.05	0.370
OM	88.29 ± 0.02cd	88.29 ± 0.03cd	88.42 ± 0.08d	88.19 ± 0.04bc	88.31 ± 0.04cd	88.37 ± 0.03d	88.07 ± 0.02b	88.10 ± 0.02b	88.17 ± 0.02bc	87.90 ± 0.03a	87.9 ± 0.03a	87.87 ± 0.02a	87.79 ± 0.01a	87.79 ± 0.00a	87.80 ± 0.00a	0.000
CP	8.37 ± 0.13a	10.27 ± 0.12b	12.37 ± 0.17c	8.59 ± 0.18a	10.25 ± 0.00b	12.38 ± 0.23c	8.35 ± 0.12a	10.05 ± 0.05b	12.59 ± 0.08c	8.50 ± 0.09a	9.95 ± 0.04b	12.69 ± 0.09c	8.30 ± 0.06a	10.59 ± 0.2b	12.40 ± 0.08c	0.000
EE	1.18 ± 0.05	1.19 ± 0.14	1.23 ± 0.04	1.21 ± 0.08	1.04 ± 0.04	1.22 ± 0.06	1.10 ± 0.08	1.03 ± 0.01	1.12 ± 0.11	1.29 ± 0.03	1.16 ± 0.05	1.27 ± 0.01	1.09 ± 0.07	1.20 ± 0.04	1.28 ± 0.15	0.373
CF	21.23 ± 0.02b	20.89 ± 0.04a	20.76 ± 0.01a	21.57 ± 0.02cd	21.31 ± 0.02bc	21.18 ± 0.01b	22.00 ± 0.06e	21.66 ± 0.02d	21.40 ± 0.14abc	22.63 ± 0.09g	22.29 ± 0.03f	22.19 ± 0.04ef	23.52 ± 0.02i	23.31 ± 0.03hi	23.17 ± 0.01h	0.000
NFE	57.51 ± 0.15l	55.95 ± 0.08ij	54.05 ± 0.21ef	56.83 ± 0.1kl	55.17 ± 0.23ghi	53.60 ± 0.22de	56.62 ± 0.1jk	55.36 ± 0.05hi	53.06 ± 0.18cd	55.49 ± 0.02hi	54.50 ± 0.11fg	51.73 ± 0.05b	54.88 ± 0.00gh	52.70 ± 0.25c	50.96 ± 0.09a	0.000
TA	11.71 ± 0.02ab	11.71 ± 0.03ab	11.58 ± 0.08a	11.81 ± 0.04bc	11.69 ± 0.04ab	11.63 ± 0.03a	11.93 ± 0.02c	11.90 ± 0.02c	11.83 ± 0.02bc	12.10 ± 0.03d	12.10 ± 0.03d	12.13 ± 0.02d	12.21 ± 0.01d	12.21 ± 0.00d	12.20 ± 0.00d	0.000
AIA	4.82 ± 0.02b	4.85 ± 0.03b	4.69 ± 0.08a	5.03 ± 0.04cd	4.90 ± 0.04bc	4.84 ± 0.03ab	5.12 ± 0.02def	5.08 ± 0.02dc	5.01 ± 0.03cd	5.25 ± 0.03ef	5.24 ± 0.03ef	5.28 ± 0.02f	5.29 ± 0.01f	5.28 ± 0.00f	5.28 ± 0.00f	0.000

(*n=3), ^{a,b,c,d,e,f,g,h,I,j,k,l} Values with different superscripts in a row differ significantly (P<0.01)

Table 4. Fibre fractions (% on DMB) of complete feeds (Mean* ±S.E)

Nutrients	CFE 1	CFE 2	CFE 3	CFE 4	CFE 5	CFE 6	CFE 7	CFE 8	CFE 9	CFE 10	CFE11	CFE12	CFE13	CFE14	CFE15	P value
NDF	57.80 ± 0.06c	56.41 ± 0.01b	55.37 ± 0.20a	60.70 ± 0.08f	59.10 ± 0.06e	58.48 ± 0.05d	62.49 ± 0.09j	61.96 ± 0.1h	61.08 ± 0.04g	64.40 ± 0.001	63.05 ± 0.04j	62.26± 0.02hi	66.71± 0.03m	64.70 ± 0.011	63.82 ± 0.00k	0.000
ADF	31.81 ± 0.06c	31.14 ± 0.01b	30.57 ± 0.01a	32.64 ± 0.01e	32.19 ± 0.00d	31.76 ± 0.00c	33.53 ± 0.04h	32.86 ± 0.02f	32.55 ± 0.01e	34.91 ± 0.02k	33.60 ± 0.00h	33.04 ± 0.03g	35.54± 0.041	34.42 ± 0.03j	34.14 ± 0.01i	0.000
ADL	5.52 ± 0.00m	5.55 ± 0.00n	5.56 ± 0.00o	5.42 ± 0.00j	5.45 ± 0.00k	5.46 ± 0.001	5.22 ± 0.00g	5.24 ± 0.00h	5.25 ± 0.00i	5.10 ± 0.00d	5.13 ± 0.00e	5.17 ± 0.00f	4.85 ± 0.00c	4.84 ± 0.00b	4.82 ± 0.00a	0.000

(*n=3), [a,b,c,d,e,f,g,h,I,j,k,l,m,n,o] Values with different superscripts in a row differ significantly ($P<0.01$)

Table 5. Invitro gas production (IVGP), in vitro dry matter degradability (IVDMD) and in vitro organic matter degradability (IVOMD) of complete feeds (Mean* ± S.E)

In vitro parameters	CFE 1	CFE 2	CFE 3	CFE 4	CFE 5	CFE 6	CFE 7	CFE 8	CFE 9	CFE 10	CFE11	CFE12	CFE13	CFE14	CFE15	P value
IVGP (ml/48 hrs)	29.86 ± 1.17	29.12 ± 0.66	30.49 ± 2.6	32.78 ± 0.74	31.90 ± 5.02	30.30 ± 0.53	30.97 ± 1.35	33.01 ± 0.84	34.33 ± 1.5	30.90 ± 0.66	31.52 ± 1.89	35.67 ± 5.33	31.85 ± 0.6	32.61 ± 1	34.22 ± 0.81	0.780
IVDMD (%)	48.75 ± 0.84	48.81 ± 0.72	49.06 ± 1.46	48.80 ± 0.7	47.79 ± 1.99	49.40 ± 1.51	49.23 ± 2.42	49.66 ± 2.37	51.01 ± 1.89	51.16 ± 0.46	51.03 ± 0.53	50.03 ± 0.93	50.81 ± 0.32	50.04 ± 0.39	50.53 ± 0.73	0.866
IVOMD (%)	58.51 ±	5.55 ± 0.00n	5.56 ± 0.00o	5.42 ± 0.00j	5.45 ± 0.00k	5.46 ± 0.00l	5.22 ± 0.00g	5.24 ± 0.00h	5.25 ± 0.00i	5.10 ± 0.00d	5.13 ± 0.00e	5.17 ± 0.00f	4.85 ± 0.00c	4.84 ± 0.00b	4.82 ± 0.00a	0.000

(*n=3), [a,b,c] Values with different superscripts in a row differ significantly ($P<0.05$)

Table.6. Two-way ANOVA table for statistical analysis of invitro gas production, in vitro dry matter degradability and in vitro organic matter degradability of complete feeds

	P Value		
Factors	**IVGP**	**IVDMD**	**IVOMD**
Level of inclusion of sugarcane tops	0.409	0.248	0.000
Crude protein level	0.440	0.819	0.590
Level of inclusion*Crude protein level (Interaction effect)	0.878	0.981	0.997

Table.7. In vitro organic matter degradability (%) at different level of inclusion of sugarcane tops (Mean* ± S.E)

Level of inclusion of sugarcane tops	IVOMD (%)
0%	**58.85 ± 0.876a**
25%	58.15 ± 0.876a
50%	59.65 ± 0.876a
75%	63.70 ± 0.876b
100%	63.83 ± 0.876b
P value	0.000

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