

Original Research Article

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Feeding Value of Ensiled Sugar Beet Pulp in Cattle

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ABSTRACT

The study was conducted to determine chemical composition and *in vitro* digestibility of sugar beet pulp (SBP) in cattle. Different ensiled SBP samples were procured from dairy farms near university and analyzed for chemical composition. Six complete diets were prepared by substituting maize fodder with SBP @ 20,40,60,80 and 100 percent and subjected to *in-vitro* gas production to estimate DM and NDF digestibility. The proximate analysis of different samples of SBP revealed that it has similar composition that of maize. The net gas production, NDF digestibility and organic matter digestibility was significantly ($P \leq 0.05$) higher at 100% of inclusion than others (266.22 ml/24 hr, 75.10% & 89.18% respectively). The ammonia level differed statistically ($P \leq 0.05$) and gradually decreased as inclusion level of SBP increased. The fermentable CO₂, fermentable CH₄ and ME was significantly ($P \leq 0.05$) higher at 80% level (49.93mmol, 32.94mmol & 9.30MJ/kg DM respectively) than the others diets. The total VFA concentration was significantly ($P \leq 0.05$) higher at 100% (6.94mM/dl). The concentration of acetate and propionate was significantly ($P \leq 0.05$) higher at 100% of inclusion (4.86mM/dl & 1.54mM/dl) while the concentration of butyrate, isobutyrate, valerate and isovalerate was significantly ($P \leq 0.05$) higher at 80% inclusion level (0.03 mM/dl, 0.43 mM/dl, 0.05 mM/dl & 0.04 mM/dl respectively). The acetate to propionate ratio was significantly ($P \leq 0.05$) higher at 80% level. It was concluded that maize fodder can be replaced by SBP completely.

Keywords

Cattle, Digestibility,
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Introduction

A major constraint of livestock production in India is the scarcity and fluctuating quantity and quality of the year-round fodder supply. At present, the country faces a net deficit of 61.1% green fodder, 21.9% dry crop residues and 64% concentrate feeds (Earagariyanna *et al.*, 2017) and this deficit is major cause of low productivity of livestock. One way to

reduce such problem is to replace the fodder with non-forage fibrous sources such as sugar beet pulp. Sugar beet pulp (SBP) is the residue left from ground sugar beet after sugar extraction.

Mirzaei-Aghsaghali and Maheri-Sis (2008) evaluated the nutritive value of SBP. Their results indicated that SBP contained 9.2% CP, 0.62% EE, 20.4% CF, 42.20% NDF, 21.97%

ADF, 1.9% lignin on dry matter basis. They also evaluated the DM, OM, and NDF digestibility of SBP in cattle which was 63.10%, 69.50% and 39.1% respectively. Kilic *et al.*, (2010) made SBP silage with different silage additives and found that 1% urea increased the protein content (212.3g/kg DM) of silage but decreased NFE content (419.7g/kg DM). Mirzaei-Aghsaghali and Maheri-Sis (2011) also studied nutritional value of SBP for ruminants and concluded that OMD, ME and NE_L were 924.3g/kg DM, 13.8MJ/kg DM and 8.684 MJ/kg DM, respectively. They concluded that SBP can be used as energy source in the diets of cattle. Mojtahedi, *et al.*, (2011) observed blood parameter of Holstein steers by adding dried molassed SBP and suggested that partial replacement of barley grain improves the ruminal environment and nutrient digestibility without affecting blood parameter. Grewal *et al.*, (2015) compared the nutritive value of SBP as silage with oat silage in ruminants and concluded that SBP is a high energy ruminant feed and digestibility of nutrient was higher than oat silage.

In Punjab, area under sugar beet cultivation is 13000 acres at Gurdaspur, Amritsar and Muksar Sahib Districts with average yield of 400 quintal per acre and producing 56000 metric tons of SBP in wet form. It has potentially high degradable neutral detergent fiber and also good amount of crude protein. Therefore, an attempt was made to evaluate nutritive value of SBP by *in vitro* techniques in dairy cattle.

Materials and Methods

Six samples of ensiled SBP were procured from dairy farmers nearby university and were analyzed for DM, CP, EE, NDF, ADF, ADL and cellulose (AOAC, 2000). Six complete diets were prepared by using maize fodder (collected from farmer), SBP (@ 20,

40, 60, 80 and 100% and concentrate on DM basis as per NRC (2001) requirements. The concentrate was prepared by using locally available ingredients. The fodder to concentrate ratio was 50:50.

All the combinations were analyzed for proximate principles (AOAC, 2000) and cell wall components (Robertson and Van Soest, 1981). The extract of ensiled SBP was prepared macerating 25g sample in 75 ml of distilled water and filtered through nylon cloth. This extract was used for estimation of pH using a digital pH meter. The buffering capacity was estimated as per Jasaitis *et al.*, (1987). The *in vitro* gas production was estimated as per Menke and Steingass (1988). For *in vitro* gas production rumen fistulated cattle fed on standard diet of concentrate mixture, green fodder and roughage served as donor animal. The rumen content was collected before feeding at 06.00am in a thermos flask flushed with CO₂ and maintained at 39°C. Then collected rumen content was strained through 4 layered muslin cloths and processed. Approximately 375 mg of sample in triplicate was placed in 100 ml calibrated glass syringe along with buffered rumen fluid. Syringes were incubated in a water bath at 39°C and swirled every 60 min. over the incubation period. Net gas production was recorded up to 24hr. After stipulated time; the contents were taken out and centrifuged. After 24 hours the NH₃-N, TVFA and NDF of residue were determined. The content of syringes was transferred to spout less beaker by repeated washing with 20 ml neutral detergent solution. The flask content was refluxed for one hour and filtered through pre weighed Gooch crucibles (grade GI). The dry matter content of the residue was weighed and *in vitro* true digestibility of feeds was calculated (Van Soest and Robertson 1988). The ME value of the substrate was calculated by using the equation developed by Menke *et al.*, 1979. At the end of 24 hour

incubation period methane was estimated by GLC by sampling the gas from the silicon tube of syringes and the liquid content was further processed for the estimation of VFA and ammonia nitrogen. VFAs were estimated using Netchrom 9100 gas chromatograph (Netal, New Delhi, India) equipped with flame ionization detector as per method described by Cottoyn and Boucque (1968). The data were analyzed (Snedecor and Cochran, 1994). Permission for animal experiments was obtained from CPCSEA, Animal Welfare Division, Ministry of Environment and Forest, GOI, New Delhi.

Results and Discussion

The average chemical composition of different procured samples of ensiled SBP, maize fodder and concentrate on DM basis are shown in table 1. CP, ASH, EE, NDF, ADF, ADL and cellulose content of SBP were 10.47, 2.9, 1.6, 59.2, 31.36, 4.5, and 25.6 present respectively whereas maize fodder contained 9.1, 3.6, 3.7, 58.0, 20.0, 3.0 and 25.6 respectively. The composition present in concentrate which was used to prepare diet had CP, ASH, EE, NDF, ADF, ADL and cellulose content as 22.2, 8.8, 4.0, 22.6, 11.6, 3.3 and 28.05 respectively. The estimated CP and ADL values of SBP were in agreement with that by De Smet *et al.*, (1995). The silage characteristic of SBP was calculated on the wet basis; the pH was found to be 3.45 and the buffering capacity was 3.92 meq/g (Table 2).

Six complete diets were prepared by using maize fodder, SBP @ 20%, 40%, 60%, 80% and 100% and concentrate on 50:50 DM basis. The chemical composition of the complete diets is given in table 3. The CP content of the diet containing 100% SBP was highest (16.35) comparable to that of 80% (16.22), 60% (16.19), 40% (16.05), 20% (15.8) respectively and was lowest in control diet (15.70). As the level of SBP was

increased the protein content of complete feed also increased (non-significantly) because of little bit higher CP value of SBP than the maize fodder. But in contrast, Ash, EE, NDF and cellulose content in complete diet decreased with increase in SBP. The maximum ash content was in the control diet (7.05) while minimum for the diet containing 100% SBP (5.05). The ash content varied with different inclusion level of SBP as 6.25 (20%), 6.10(40%), 5.75 (60%), 5.38 (80%) and 5.05 (100%) respectively. The EE content was comparable between the diets and was highest for control (2.55) and 100% (2.55) followed by 20% (2.60), 40% (2.45), 60% (2.45), and 80% (2.35) respectively. The NDF content was variable in the diets as 31.9 (80%), 32.3 (100%), 32.5 (60%), 36.1 (40%), 39.5 (0%), and 39.7 (20%) respectively. The cellulose was highest in control diet (20.6) followed by 20% (19.8), 60 (19.2), 40 (18.3), 80 (17.3) and was least in 100% (16.4).

Net gas production (ml/24hr)

The *in vitro* rumen fermentation parameters of ensiled SBP are given in table 4. The *in vitro* study indicated that the net gas production (NGP) was increased significantly ($P \leq 0.05$) from 163.33 ml to 266.22 ml as the concentration of SBP was increased. The NGP was significantly ($P \leq 0.05$) higher for 100% (266.22) followed by 80% (260.00), 60% (236.89), 40% (200.00), 20% (193.33) and control (163.33) respectively. The results revealed that as the level of SBP increased there was increase in NGP indicating active fermentation in all diets.

NDF digestibility (%)

NDF digestibility was higher for 100% (75.10) followed by 40% (67.61), 80% (65.95), 60% (60.78), 0% (52.60) and 20% (49.00). The similar results were observed by Voelker and Allen (2003b) and they

concluded that potentially digestible NDF was digested more extensively and at a faster rate in the rumen with increasing beet pulp, resulting in increased total tract NDF digestibility. The organic matter digestibility (TOMD) differed significantly ($P \leq 0.05$) in

similar manner that of the NDF digestibility. TOMD was highest for 100% (89.18) followed by 80% (85.16), 40% (84.22), 60% (82.70), 0% (75.10) while least for 20% (73.70).

Table.1 Average chemical composition of ensiled SBP, Maize fodder and concentrate (DM Basis)

Parameter (%)	Ensiled SBP	Maize Fodder	Concentrate
CP	10.47	9.1	22.2
EE	1.6	3.7	4.0
ASH	2.9	3.6	8.8
NDF	59.2	58.0	22.6
ADF	31.36	20.0	11.3
ADL	4.5	3.0	3.3
CELLULOSE	25.6	23.4	28.05

Table.2 Chemical composition of diets replacing maize with ensiled SBP (DM Basis)

Parameter (%)	0%	20%	40%	60%	80%	100%
ASH	7.05	6.25	6.1	5.75	5.375	5.05
CP	15.7	15.8	16.05	16.19	16.22	16.35
EE	2.55	2.60	2.45	2.45	2.35	2.55
NDF	39.5	39.7	36.1	32.5	31.9	32.3
CELLULOSE	20.6	19.8	18.3	19.2	17.3	16.4

Table.3 The *In vitro* Rumen Fermentation Parameters of Ensiled SBP Replacing Maize

	SBS:MF						PSE
	0:100	20:80	40:60	60:40	80:20	100:0	
NGP (ml/24 hrs)	163.33 ^a	193.33 ^{ab}	200.0 ^c	236.89 ^{cd}	260.0 ^d	266.22 ^d	9.29
NDFD (%)	52.60 ^a	49.00 ^a	67.61 ^c	60.78 ^b	65.95 ^c	75.10 ^d	2.70
TOMD(%)	75.10 ^a	73.70 ^a	84.22 ^c	82.70 ^b	85.16 ^c	89.18 ^d	1.91
PF	2.30 ^d	1.91 ^c	1.87 ^c	1.54 ^b	1.42 ^a	1.39 ^a	0.10
NH3(mg/dl)	0.030 ^c	0.028 ^{ab}	0.027 ^a	0.026 ^a	0.028 ^{ab}	0.026 ^a	-
Ferm CO ₂ (mmol)	48.95 ^a	49.18 ^b	49.34 ^c	49.68 ^e	49.93 ^f	49.62 ^d	0.1
Ferm CH ₄ (mmol)	32.36 ^b	32.01 ^a	32.39 ^b	32.82 ^d	32.94 ^e	32.47 ^c	0.09
ME (MJ/kg DM)	7.32 ^a	8.03 ^{abc}	7.87 ^{ab}	8.75 ^{bcd}	9.30 ^{cd}	9.48 ^d	0.22
TVFA (mM/dl)	5.40 ^a	6.42 ^c	6.12 ^b	6.76 ^d	6.88 ^e	6.94 ^f	0.16

*Mean values within a row with no common superscript differ significantly

Table.4 *In vitro* volatile fatty acids production (Mm/Dl) of different inclusion levels of ensiled SBP

	SBS:MF						PSE
	0:100	20:80	40:60	60:40	80:20	100:0	
Acetate (A) (mM/dl)	3.80 ^a	4.47 ^c	4.29 ^b	4.76 ^d	4.84 ^e	4.86 ^f	0.11
Propionate(P)(mM/dl)	1.20 ^a	1.46 ^c	1.37 ^b	1.47 ^d	1.47 ^d	1.54 ^e	0.03
Iso butyrate(mM/dl)	0.026 ^a	0.030 ^{bc}	0.027 ^a	0.030 ^c	0.035 ^d	0.029 ^b	-
Butyrate(mM/dl)	0.295 ^a	0.371 ^c	0.354 ^b	0.406 ^d	0.432 ^f	0.420 ^e	0.01
Isovalerate(mM/dl)	0.044 ^{ab}	0.049 ^c	0.043 ^a	0.048 ^c	0.055 ^d	0.045 ^b	0.001
Valerate(mM/dl)	0.032 ^a	0.038 ^c	0.037 ^b	0.044 ^d	0.048 ^f	0.046 ^e	0.002
A:P	3.16 ^d	3.06 ^a	3.14 ^b	3.25 ^e	3.28 ^f	3.15 ^c	0.02

*Mean values within a row with no common superscript differ significantly

Table.5 The relative proportion of VFA from *in vitro* study

	SBS:MF						PSE
	0:100	20:80	40:60	60:40	80:20	100:0	
Acetate (%)	70.38 ^e	69.63 ^a	70.16 ^c	70.48 ^f	70.31 ^d	69.99 ^b	0.08
Propionate(%)	22.27 ^d	22.77 ^t	22.32 ^e	21.69 ^b	21.39 ^a	22.21 ^c	0.13
Iso butyrate (%)	0.49 ^e	0.46 ^d	0.43 ^b	0.45 ^c	0.51 ^f	0.42 ^a	0.01
Butyrate (%)	5.46 ^a	5.78 ^b	5.78 ^b	6.01 ^c	6.28 ^e	6.05 ^d	0.08
Isovalerate (%)	0.81 ^d	0.76 ^c	0.70 ^b	0.71 ^b	0.80 ^d	0.65 ^a	0.02
Valerate (%)	0.59 ^a	0.60 ^{ab}	0.60 ^b	0.65 ^c	0.70 ^e	0.67 ^d	0.01

*Mean values within a row with no common superscript differ significantly

Partition factor

The partitioning factor (PF) is the ratio of organic matter degraded (mg) *in vitro* to the volume of gas (ml) produced. A higher partitioning factor means that proportionally more of the degraded matter is incorporated into microbial mass i.e. the efficiency of microbial protein synthesis is higher. The partition factor calculated *in vitro* provides useful information for predicting the dry matter intake, microbial mass production in the rumen and the methane emission of the whole ruminant animal. In this study PF value was lower ($P \leq 0.05$) in 100% inclusion level (1.39) succeeded by 80% (1.42), 60% (1.54), 40% (1.87), 20% (1.91) and was highest significantly ($P \leq 0.05$) in diet containing no SBP (2.30).

Ammonia concentration (mg/dl)

As the concentration of SBP in the diet increased the ammonia concentration decreased from 0.30% to 0.26%. The diet containing 100% SBP had minimum (0.026) ammonia concentration was statistically similar to the diets with different inclusion level i.e., 60% (0.026), 80% (0.028), 20% (0.028) and 40% (0.027). The maize fodder diet had statistically ($P \leq 0.05$) higher ammonia concentration (0.030) than all the diets. Our results were supported by Omara *et al.*, (1997), Mojtahedi and Mesgaran (2011). They reported decrease in mean ruminal ammonia concentration in similar manner. It indicated the protein present in diet was efficiently utilized by rumen micro flora for its conversion to microbial protein.

Fermentable CO₂, fermentable CH₄ (mmol) and ME (MJ/kg DM)

The fermentable CO₂ and fermentable CH₄ differed significantly ($P \leq 0.05$) and were higher for the diet containing 80% SBP. The fermentable CO₂ was highest for 80% (49.93) followed by 60% (49.68), 100% (49.62), 40% (49.34), 20% (49.18) and 0% (48.95). The fermentable CH₄ was highest for 80% (32.94) followed by 60% (32.82), 100% (32.47), 40% (32.39), 20% (32.01) and 0% (32.36). ME varied statistically in same manner and was significantly ($P \leq 0.05$) highest at 100% (9.48) followed by 80% (9.30), 60% (8.75), 20% (8.03), 40% (7.87) and was least in diet with no SBP (7.32).

***In vitro* volatile fatty acids production (mM/dl) of different inclusion level of ensiled SBP**

The profile of total VFA evaluated is presented in table 4. Total volatile fatty acids varied statistically and was significantly ($P \leq 0.05$) highest at 100% (6.94) followed by 80% (6.88), 60% (6.76), 20% (6.42), 40% (6.12) and least at 0% (5.40) inclusion respectively. The increase in total volatile fatty acid indicated that there was increase in carbohydrate fermentation due to increasing concentration of reducing sugars. Acetate and propionate was significantly ($P \leq 0.05$) higher for 100% (4.86 and 1.54 respectively) while butyrate, valerate and isovalerate were significantly ($P \leq 0.05$) higher at 80% (0.432, 0.048, 0.055). As SBP increased in the diets there was increase in the acetate and propionate concentration being maximum at 100% (4.86 and 1.54) followed by 80% (4.84 and 1.47), 60% (4.76 and 1.47), 20% (4.47 and 1.46), 40% (4.29 and 1.37) and minimum in control diet (3.80 and 1.20) respectively. The isobutyrate concentration were statistically ($P \leq 0.05$) similar among the diets being highest at 80% (0.035), followed by

20% (0.030), 60% (0.030), 100% (0.029), 40% (0.027) and least at 0% (0.026) inclusion respectively. The butyrate concentration was higher for the diet containing 80% (0.432) of SBP followed by 100% (0.420), 60% (0.406), 20% (0.371), 40% (0.354) and least for the diet containing no SBP (0.295). The isovalerate varied statistically ($P \leq 0.05$) in similar manner being minimum for 40% (0.043) succeeded by 0% (0.044), 100% (0.045), 60% (0.048), 20% (0.049) and maximum for 80% (0.55 and 0.048) respectively. The valerate varied statistically ($P \leq 0.05$) in similar manner being maximum for 80% (0.048) followed by 100% (0.046), 60% (0.044) 20% (0.038), 40% (0.037), and minimum for control diet (0.032) respectively. In *in vitro* experiments, Mansfield *et al.*, (1994) reported greater acetate and lower butyrate concentrations with BP replacing corn grain and with no effect on propionate concentration. However, comparing ground BP and corn grain in TMR, Clark and Armentano (1997) found that acetate, propionate and butyrate had similar concentration. Voelker and Allen (2003c) reported that both slower absorption of VFA and slower liquid passage from the rumen led to higher VFA concentrations in the rumen. The acetate to propionate ratio differed statically and significantly ($P \leq 0.05$) higher at 80% (3.28) followed by 60% (3.25), 0% (3.16), 100% (3.15), 40% (3.14) and least at 20% (3.06).

The change in acetate and propionate concentration in the buffered rumen fluid depends on the passage rate in the rumen. Similar to the results, many researchers (Erdman *et al.*, 1980; West *et al.*, 1987; Staples *et al.*, 1988) have the reported that the buffering agents increased acetic acid, decreased propionic acid concentrations in the rumen thus caused a high acetic/ propionic acid ratios in dairy cows.

The Relative Proportion of VFA is presented in table 5. It was observed that acetate production differed significantly ($P \leq 0.05$) in each diet. It was maximum at 60% (70.48) level followed by control (70.38), 80% level (70.31), 40% level (70.16), 100% level (69.99) and minimum at 20% (69.63). Propionate also varied significantly ($P \leq 0.05$) with every diet. It was highest at 20% (22.77) followed by 40% (22.32), diet with no SBP (22.27), 100% (22.21), 60% (21.69) and diet containing 80% (21.39) was at least. Butyrate, isobutyrate and valerate were higher in 80% (6.28, 0.51 and 0.70 respectively). Isobutyrate was minimum at 100% (0.42) succeeded by 40% (0.43), 60% (0.45), 20% (0.46), no SBP diet (0.49) and maximum at 80% (0.51). The isobutyrate concentration was significantly higher at 80% (6.28) followed by 100% (6.05), 60% (6.01), 20% and 40% were similar (5.78) and was least at control diet (5.46). The valerate level varied in the diet as 0.70 (in 80%), 0.67 (100%), 0.65 (60%) followed by similar levels in diets with 20% (0.60) and 40% (0.60) levels of SBP respectively. Isovalerate was higher in diet with no SBP (0.81) followed by 80% (0.80), 20% (0.76), 60% (0.71), 40% (0.70) and was minimum for diet with 100% SBP (0.67).

The IVGPT results clearly indicated that maize fodder can be completely replaced with sugar beet pulp.

In conclusion the SBP is rich source of potentially degradable neutral detergent fiber (NDF) and crude protein and also superior in digestibility. Thus, SBP can be used as roughage for ruminants by replacing maize fodder completely.

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