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Effect of Soybean Straw and Seaweed (*Sargassum johnstonii*) Based Total Mixed Ration on Feed Intake, Digestibility and Rumen Fermentation in Crossbred Cows

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ABSTRACT

An experiment was conducted to evaluate the effect of soybean straw and seaweed supplementation on feed intake, nutrient digestibility and rumen fermentation in lactating crossbred cows. Six Holstein Friesian × Kankrej (50:50) crossbred cows were used in an experiment based on switch over design for 135 days with three periods each of 45 days duration. The animals received three treatments as total mixed ration *viz.* T_1: TMR with compound concentrate mixture (60%) and wheat straw (40%); T_2: TMR with compound concentrate mixture (60%), wheat straw (20%) and soybean straw (20%); T_3: TMR with 8% seaweed (*Sargassum johnstonii*). Dry matter (DM) and digestible crude protein intake were at par in T_1 and T_2, but significantly (P<0.05) lower in T_3 while total digestible nutrients intake differed significantly (P<0.05) among all groups. There was no significant difference in nutrient digestibility except lower (P<0.05) DM digestibility in group T_3. Rumen fermentation parameters were also similar among the treatment groups except that total volatile fatty acids (TVFA) concentration was significantly lower (P<0.05) in group T_3. Microbial protein synthesis was also similar in all the groups. The study revealed low feed intake, TVFA and dry matter digestibility in seaweed supplemented group.

Key words: Digestibility, Rumen fermentation, Seaweed, Soybean straw, TMR

INTRODUCTION

Seaweeds are macroalgae having different shapes, sizes, colour and composition, and are inhabitant of littoral zone of aquatic ecosystem (Bast, 2014). Seaweeds are rich sources of essential amino acids, vitamins like A, B_1, B_2, B_3, B_{12}, C, D, E, ω-3 fatty acids and various biologically active compounds essential for life and maintaining good health (Yende *et al.,* 2014). In India, seaweeds are less utilized as traditional livestock feed but nowadays research is aimed to use seaweed resources as feed additive and supplement (Singh *et al.,* 2015; Munde *et al.,* 2019; Sharma and Datt, 2020; Maheswari *et al.,* 2021). However, response of seaweed supplementation depends on many factors like species and physiological satatus of the animal, species and doses of the seaweed, and processing methods employed during the preparation of seaweed meal (Makkar *et al.,* 2016). Fibrous crop residues are valuable feed resources, but poor nutritive value and digestibility restrict their utilization. Legume straw are better than cereal straws due to more protein and energy content as well as more digestibility and less methane production (Beauchemin *et al.,*2008, Prajapati, 2016; Khare *et al.,* 2018; Jasvantgiri, 2019). Considering the benefits of feeding of legume straw and seaweeds on animal performance it would be pertinent to evaluate both these feed ingredients as feed supplement for ruminants. Hence, the present study was undertaken to study the effect of seaweed and soybean straw based TMR on dry matter and nutrient intake, nutrient digestibility and rumen fermentation in crossbred dairy cows.

MATERIALS AND METHODS

The experiment was conducted on six Holstein Friesian X Kankrej (50:50) crossbred cows using switch over design with three periods of 45 days each. After 45 days, the animals were switched over to another treatment. Thus, each treatment had 6 observations. However, one animal was removed from the experiment due to sickness hence data were compiled for 5 animals in each treatment. Permission was granted by Institutional Animal Ethics Committee (IAEC/310/

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Table 1. Ingredient composition (%) of total mixed rations

Ingredients	T_1(Control)	T_2(Soybean Straw)	T_3(Seaweed)
Wheat straw	40.0	20.0	40.0
Soybean straw	0.0	20.0	0.0
Compound Concentrate Mixture	46.0	40.0	46.0
De oiled Rice Bran	8.0	10.0	0.0
Seaweed (*S. johnstonii*)	0.0	0.0	8.0
Molasses	5.0	9.0	5.0
Mineral mixture	1.0	1.0	1.0

ANRS/2019) to conduct the experiment. The dried biomass of seaweed was procured from local vender in Veraval, Gujarat. The treatments were T_1: TMR with concentrate mixture and wheat straw (60:40); T_2: TMR with 20 % each of wheat straw and soyabean straw and 60% concentrate mixture and T_3: TMR (60:40) with seaweed (*Sargassum johnstonii*) at 8%. The ingredients composition is presnted in Table 1. Quantity of TMR offered was to meet nutrient requirement as per ICAR (2013) feeding standards. The quantity of TMR required each day was offered in two instalments *i.e.* half in morning and remainder in the evening.

Daily feed intake and leftover were recorded for each animal. The DM and nutrient intake were calculated. Body weight (BW) was measured fortnightly in morning before feeding and watering using electronic weighing machine. In the last week of each period, a digestion trail was conducted on all the animals to determine digestibility of nutrients. Representative samples of feed and faeces were collected and analysed for proximate principles as per AOAC methodology (AOAC, 2016) and fibre fraction by Van Soest method (Van Soest *et al.,* 1991). Rumen liquor was collected at 0, 3 and 6 hrs post feeding through stomach tube against negative pressure created by suction pump and strained through four-layer muslin cloth for chemical analysis. Rumen pH was estimated immediately after collection by portable digital pH meter. The total and soluble nitrogen (N) was estimated by Kjeldahl's method, non-protein nitrogen by trichloroacetic acid precipitation, ammonia N by Pearson and Smith (1943) and total volatile fatty acid (TVFA) by steam distillation method using Markham micro distillation apparatus. Urine samples (100 ml) from individual animal was collected in each period and analysed for allantoin, uric acid and creatinine using spectrophotometer (Young and Conway, 1942). Purine derivatives (PD) were measured by spot sample test based on the fact that excretion of creatinine is constant throughout a day, therefore, creatinine was used as an internal marker for estimation of PD (Chen *et al.,* 1992). Daily excretion of creatinine was considered as 0.98 mmol/kg $W^{0.75}$ and microbial N supply was calculated from the daily urinary PD excreted (IAEA, 1997).

The experimental data were analysed as per methods of Snedecor and Cochran (1994) by analysis of variance (ANOVA) using General Linear Model (GLM) procedure with the help of SAS software programme.

RESULTS AND DISCUSSION

The intake of dry matter (DM), crude protein (CP), digestible crude protein (DCP) and total digestible nutrients (TDN) are presented in Table 2. Average daily DM intake (DMI) was significantly ($P<0.01$) lower by 10.35% in T_3 than T_1. Similar trend was also observed for DMI (% of BW) which decreased by 8.75 % in cows fed seaweed compared to control group. The DMI was less in T_3 which may be due less palatability of seaweed. This was evident from the observations that in each period, irrespective of animals, the DMI decreased in T_3 group in last two weeks of period. This indicated less acceptance of seaweed based TMR by animals for longer period. Due to less DMI, the nutrient intake also decreased in T_3. The intake of CP, DCP and TDN were lower by 13.5, 11.1 and 11.2 % respectively

Table 2. Nutrient intake and body weight changes in crossbred cows

Parameter	T_1	T_2	T_3	SEM	P -value
DMI (kg/d)	12.56^{A}	12.25^{A}	11.26^{B}	0.109	0.0004
DMI (kg/100 kg BW)	3.20^{A}	3.08^{B}	2.92^{C}	0.021	0.0003
CPI (kg/d)	1.48^{A}	1.38^{A}	1.28^{B}	0.032	0.0007
DCPI (kg/d)	0.90^{A}	0.88^{A}	0.80^{B}	0.009	0.0006
TDNI (kg/d)	6.44^{A}	6.15^{B}	5.72^{C}	0.049	0.0002
Body weight (kg)	398.90	399.72	401.37	0.109	0.6747
Body weight gain (kg/d)	0.53^{A}	0.57^{A}	0.24^{B}	1.905	0.0499

^{A,B,C} Mean having different superscript in a row differ significantly; DMI, dry matter intake; CPI, crude protein intake; DCPI, digestible crude protein intake; TDNI, total digestible nutrient intake

in T_3 than T_2. The literature regarding feeding seaweed to cows has shown variable responses. Roque *et al.* (2019) observed significant (P<0.001) decrease in dry matter intake of Holstein cows by 10.8 and 38.0 % at low (0.5%) and high (1%) level of *Asparagopsis armata* inclusion, respectively compared to control group. Kinley *et al.,* (2020) also reported 10.8 % reduction in DM intake in steers fed ration with 0.05% *Asparagopsis taxiformis*. However, other reports did not find any significant difference in DMI of cows (Baek *et al.,* 2015; Hong *et al.,* 2015; Sharma and Datt, 2020) and buffaloes (Maheswari *et al.,* 2021) when fed with seaweed products. Similarly, Singh *et al.* (2015) observed that supplementation of brown seaweed (*Sargassum wightii*) in the diet of lactating Sahiwal cows to the extent of 20 % in concentrate mixture did not cause any significant difference in DM, DCP, and TDN intake and body weight changes among treatment groups. No adverse effect of soyabean straw on DM and nutrient intake was observed in present study. Mudgal *et al.* (2010) also reported non-significant difference in DM intake in crossbred cows when soybean straw replaced wheat straw up to 50 and 75% level. Similarly, feeding of Lucerne straw (Lunagariya *et al.,* 2016; Jasvantgiri, 2019) and groundnut straw (Prajapati, 2016; Sherasia *et al.,* 2018) based TMR did not result in any significant change in DM, DCP and TDN intake in large ruminants compared to only wheat straw based TMR. Khare *et al.* (2018) reported significantly higher intake of DM, DCP and TDN in cows with 20% inclusion level of soyabean straw.

Data pertaining to the apparent digestibility of nutrients is presented in Table 3. There was no significant difference in digestibility of organic matter (OM), CP, ether extract (EE), crude fibre (CF), and nitrogen-free extract (NFE) among treatments. However, DM digestibility was significantly (P<0.05) lower in T_3 by 21.54 % than T_1. Optimum DM and nutrient intake are necessary for better rumen fermentation and substrate degradation. In our study,

Table 3. Digestibility coefficient of nutrients

Parameter	T_1	T_2	T_3	SEM	P value
DM	56.80^{A}	49.65^{B}	46.73^{B}	1.07	0.02
OM	55.99	52.62	56.28	1.27	0.14
CP	62.81	57.51	62.31	2.10	0.208
EE	70.53	68.37	68.11	2.09	0.68
CF	42.72	38.94	46.09	2.18	0.13
NFE	52.53	48.56	50.57	1.40	0.19

^{A,B,} Mean having different superscript in a row differ significantly; DM, dry matter, OM, organic matter; CP, crude protein; EE, ether extract; CF, crude fibre; NFE, nitrogen-free extract

Table 4. Rumen fermentation parameters in crossbred cows

Particular	T_1	T_2	T_3	SEM	P value
pH	6.87	7.04	7.00	0.06	0.180
Total N	91.93	100.49	91.00	4.85	0.360
NH_3N	18.36	19.06	18.43	1.05	0.878
Soluble N	13.30	13.46	13.22	0.31	0.870
NPN	29.09	28.31	28.16	0.64	0.570
TVFA	13.93^{A}	14.62^{A}	12.53^{B}	0.36	0.010

^{A,B,} Mean having different superscript in a row differ significantly; NPN, non-protein nitrogen; TVFA, total volatile fatty acids

the DM and nutrient intake were significantly lower in seaweed (T_3) fed group which may have affected rumen fermentation and DM digestibility. This is further confirmed from lower TVFA production in T_3. Replacement of 20 % of mineral mixture in concentrate with *Sargassum wightii* (Singh *et al.,* 2015) and *Kappaphycus alvarezii* based seaweed product (Sharma and Datt, 2020) in dairy cows and supplementation of tropical seaweed based formulation in lactating buffaloes (Maheswari *et al.,* 2021) did not cause any adverse effect on digestibility of nutrients. However, Bendary *et al.* (2013) reported better digestibility of nutrients with supplementation of seaweeds at 50 g/day in Friesian cows. Supplementation of soybean straw (T_2) in TMR replacing wheat straw had no adverse effect on digestibility of nutrients. Khare *et al.* (2018) also reported no significant effect of supplementing soyabean straw up to 20% in the ration of crossbred cows on digestibility of nutrients. Sherasia *et al.* (2018) in cattle and Chaudhari (2019) in crossbred calves also reported no adverse effect of replacing wheat straw by groundnut straw, respectively on digestibility of nutrients which corroborates with the present findings.

The average values of rumen pH, nitrogen fractions and total volatile fatty acids (TVFA) are depicted in Table 4. All the parameters, except TVFA, were at par among the groups and within the normal range. Volatile fatty acids in rumen are produced during anaerobic fermentation of feeds and fodder. Total volatile fatty acid production was significantly ($P<0.01$) reduced in T_3 group which may be due to less DM and nutrient intake and digestibility of DM. Hong *et al.* (2015) also reported decrease in VFA production at 24 h of incubation in Holstein cows at 4% level of brown seaweed. However, Bendary *et al.* (2013) observed higher TVFA and low NH_3-N in Friesian cows supplemented sea weeds at 50 g seaweed/day. Kinley *et al.* (2020) in beef steers and Li *et al.* (2018) in sheep observed no adverse effect of supplementation of seaweed (*Asparogopsis spp.*) on rumen fermentation. Legume straws are likely to improve rumen

Table 5. Microbial protein synthesis in crossbred cows

Parameter	T_1	T_2	T_3	SEM	P value
Allantoin (mmol/l)	4.17^{A}	3.39^{B}	3.87^{B}	0.13	0.020
Uric acid (mmol/l)	0.34	0.41	0.37	0.02	0.220
Creatinine (mmol/l)	1.89^{A}	1.74^{A}	2.47^{B}	0.09	0.040
Total PD excreted (mmol/l)	186.57	206.58	178.53	14.8	0.556
PDC index	190.36	210.80	190.38	15.1	0.556
Absorbed purine (mmol/l)	205.47	226.53	194.85	17.3	0.581
Microbial protein supply (g/d)	149.38	164.69	141.66	12.5	0.580

PD, purine derivatives

fermentation due to their better nutritive value and digestibility. However, in present study, replacement of wheat straw by soyabean straw did not reveal any effect on rumen fermentation. Similar to our findings, Sherasia *et al.* (2018) in crossbred cattle and Prajapati (2016) in Surti buffalo observed no significant difference in rumen fermentation parameters due to feeding of ground nut straw based straw TMR as compared to wheat straw based TMR.

Urinary PD measurement is an indirect method for estimating rumen microbial N supply to small intestine (Chen *et al.,* 1992). The microbial N was more or less similar in all the groups (Table 5). Allantoin concentration was 23.0 % and 7.75% higher ($P<0.05$) in T_1 due to higher DM intake and digestibility. Creatinine excretion was more in seaweed group than others which contradicted with other studies as linear relationship had been observed in DMI with creatinine excretion (Chizzotti *et al.,* 2008; Whittet *et al.,* 2019). The total PD excretion was apparently higher (>10%) in T_2 group as compared to T_1 and T_3 group. Sherasia *et al.* (2018) reported increase in microbial protein ($P<0.01$) synthesis in crossbred cattle when 50% of wheat straw in TMR was replaced by groundnut straw.

CONCLUSIONS

It may be concluded that supplementation of soyabean straw in TMR replacing 50 % wheat straw has no adverse effect on nutrient intake, digestibility, rumen fermentation and microbial protein synthesis. However, incorporation of brown seaweed (*S. johnstonii*) at 8% in TMR has adverse effect on palatability due to which DM intake, digestibility and VFA production was adversely affected. Hence, further research is needed to increase palatability of seaweed and to determine optimum level of incorporation so that it can be effectively utilized in livestock ration.

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