



Preparation of paddy straw based complete feed pellets and their impact on the performance of buffalo calves

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About 116 million tonnes of paddy straw is produced in India (ARDB 2019) taking grain to straw ratio 1:1. The manual collection of paddy straw from the field is labour oriented; therefore more than 80-85% of paddy straw is burnt in the field itself, confirming that it is a conventional method of its disposal in many paddy-cultivated countries (Trinh *et al.* 2017). Burning paddy straw has deleterious impact on the human health, soil health and fertility besides causing environmental pollution (Kumar *et al.* 2015). Therefore, efforts were made to find suitable alternate methods for its utilization. At the moment conversion to nutritionally enriched complete feed pellets is one of the best methods.

Complete feed pellets containing paddy straw up to 90% were prepared successfully. The *in vitro* evaluation revealed that with the increase in level of paddy straw in pellets, the ash and ADF content increased linearly, while OM, CP and EE decreased (Bakshi and Wadhwa 2021). Till date there is no report on the preparation of iso-nitrogenous and iso-caloric rice straw based complete feed pellets and their impact on the performance of ruminants. This study was therefore planned to prepare iso-nitrogenous and iso-caloric complete feed pellets containing 25 to 45% paddy straw and to assess their impact on the performance of buffalo calves.

Three concentrate mixtures with varying CP and EE were prepared. Iso-nitrogenous and iso-caloric complete feed pellets containing 25, 35 and 45% paddy straw, alfalfa hay and concentrate mixtures were prepared in a pelleting plant (Table 1). The roughage to concentrate ratio in the pellets was maintained at 65:35. The sundried paddy straw and alfalfa hay were ground in a hammer mill and lifted in a bucket elevator to the mixer where these feedstuffs were mixed with concentrate mixture. Then pellets were prepared by using 'Vertical type pellet mill' with 'Top driven technology' fitted with 8 mm stationary die, 'double start alloys steel worm' and gear set with closed precision fitting.

The bulk density of pellets was calculated (Liu *et al.* 2013).

The nutritional value of iso-nitrogenous and iso-caloric paddy straw based complete feed pellets was evaluated by *in vitro* gas production technique (IVGPT; Menke *et al.* 1979). Three rumen fistulated male buffalo calves used as donor for rumen liquor were maintained on 2 kg conventional concentrate mixture (Maize 32, barley 20, soybean meal 15, groundnut extraction 15, rice bran 15, mineral mixture 2 and common salt 1% each), 2 kg green fodder and *ad lib.* wheat straw. About 375±5 mg finely ground pellets were incubated in triplicate in a water bath at 39°C for 24 h in 100 ml calibrated glass syringes (Haberle Labortechnik, Germany) with buffered rumen fluid. After 24 h, the volume of gas produced in each syringe was recorded and the contents of syringes were transferred to spout-less beaker, boiled with neutral detergent solution for assessing the true OM digestibility.

Twelve male buffalo calves (Live weight 98.44±1.44 kg) divided in to three equal groups were fed iso-nitrogenous and iso-caloric complete feed pellets containing 25, 35 or 45% paddy straw *ad lib.* for 104 days as per NRC (2001) feeding standard. A 7 day digestion-cum-metabolism trial was conducted in specially designed metabolic cages where urine and faeces were collected automatically in separate containers. The finely ground samples of feed offered, refusal if any and faeces were analyzed for proximate constituents (AOAC 2007), cellulose (Crampton and Maynard 1938) and other cell wall components (Van Soest *et al.* 1991).

Rumen liquor was collected from buffalo calves by using Oro-ruminal collection technique (Klopp *et al.* 2018) four hours postprandial. The volatile fatty acids in the rumen liquor were estimated by using gas chromatograph (Cottyn and Boucque 1968). Further, fermentation attributes related to hydrogen recovery, VFA utilization index, efficiency of conversion of fermented hexose energy to VFA and efficiency of conversion of fermented hexose energy to methane energy were calculated by adopting procedures described in an earlier publication (Wadhwa *et al.* 2021). Data were analyzed by one way ANOVA (Snedecor and Crochan 1994) by using SPSS (2009) version 16 and the

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Table 1. Ingredient and chemical composition of paddy straw based iso-nitrogenous and iso-caloric complete feed pellets

Constituent	CFP-25*	CFP-35	CFP-45
<i>Ingredients (%)</i>			
Concentrate mixture	35.0 ¹	35.0 ²	35.0 ³
Alfalfa hay	40.0	30.0	20.0
Paddy straw	25.0	35.0	45.0
<i>Chemical composition (% DM basis)</i>			
Ash	12.70	13.55	12.85
Organic matter	87.30	86.45	87.15
Crude protein	12.75	12.65	12.45
Ether extract	3.50	3.60	3.30
Neutral detergent fibre	59.68	60.70	62.06
Acid detergent fibre	36.50	37.02	37.59
Cellulose	22.32	23.17	24.05
Hemicellulose	23.18	23.68	24.47

*CFP-25, Complete feed pellets containing 25% rice straw; CFP-35, complete feed pellets containing 35% rice straw; CFP-45, complete feed pellets containing 45% rice straw; concentrate mixture^{1, 2 & 3} contained maize 23, 26 & 19%; wheat 13, 13 & 9%; deoiled mustard cake 0, 15 & 10%; mustard cake 7, 5 & 12%; soybean meal 0, 5 & 15%; rice bran 33, 33 & 32%; deoiled rice bran 21, 0 & 0%; salt 1, 1 & 1%; mineral mixture 2, 2 & 2%, respectively.

differences in means were tested by Tukey's-b test.

The CP and EE content in concentrate mixtures varied between 14.72 to 22.68% and 6.98 to 7.18% respectively. The comparable CP and EE content in paddy straw based complete feed pellets indicated that these pellets were iso-nitrogenous and iso-caloric. The cell wall constituents of different pellets were also comparable (Table 1).

The bulk density of complete feed pellets increased with the increase in paddy straw level and was highest ($p < 0.05$) in pellets containing 45% rice straw (Table 2). The results revealed that the net gas production (NGP) and true OM digestibility decreased linearly with the increase in the paddy straw from 25 to 45% in the pellets. These parameters were statistically comparable between pellets containing 25 and 35% paddy straw, as well as between those containing 35 and 45% paddy straw, but were depressed significantly ($P < 0.05$) in pellets containing 45% paddy straw as compared to those containing 25% paddy straw. Similar trend was observed in case of ME content, but the differences were non-significant.

The daily DM intake decreased linearly with the increase in level of paddy straw in the complete feed pellets. The intake was statistically comparable in buffalo calves fed pellets containing 25 and 35% paddy straw, but higher ($P < 0.05$) than those containing 45% paddy straw (Table 2). The digestibility of DM, CP, EE and ADF decreased ($P < 0.05$) linearly with the increase in level of paddy straw. But the digestibility of these nutrients was statistically comparable in pellets containing 25 and 35% paddy straw as well as those containing 35 and 45% paddy straw. But EE digestibility was depressed ($P < 0.01$) in animals fed pellets containing 45% paddy straw as compared to those

Table 2. Bulk density, *in vitro* evaluation, DM intake, digestibility of nutrients and N-retention in buffalo calves fed paddy straw based complete feed pellets

Constituent	CFP-25*	CFP-35	CFP-45	PSE	P value
Bulk density (kg/m ³)	594.30 ^a	604.00 ^{ab}	609.20 ^b	2.70	0.045
<i>In vitro evaluation of paddy straw based complete feed pellets</i>					
Net gas production (ml/g DM/24h)	146.67 ^b	143.56 ^{ab}	136.89 ^a	1.76	0.035
True organic matter digestibility (%)	66.53 ^b	65.13 ^{ab}	63.50 ^a	0.59	0.044
Metabolizable energy (MJ/kg DM)	6.86	6.81	6.57	0.08	0.109
<i>Utilization of nutrients in buffalo calves</i>					
DM intake (kg/day)	3.15 ^b	3.04 ^b	2.08 ^a	—	0.016
<i>Digestibility of nutrients (%)</i>					
Dry matter	46.56 ^b	39.68 ^{ab}	30.64 ^a	2.88	0.047
Organic matter	49.21	44.56	37.34	2.28	0.079
Ether extract	58.66 ^b	52.99 ^b	36.10 ^a	3.93	0.037
Crude protein	56.11 ^b	52.81 ^{ab}	46.66 ^a	1.88	0.017
Neutral detergent fibre	45.60	38.82	31.48	2.68	0.076
Acid detergent fibre	41.66 ^b	36.94 ^{ab}	24.60 ^a	3.16	0.043
Cellulose	44.97	41.95	36.30	2.25	0.318
<i>Nitrogen retention (g/day)</i>					
N intake	64.29 ^b	61.39 ^b	40.01 ^a	4.24	0.006
Faecal N	28.11	28.98	21.34	1.54	0.058
Digestible N	36.17 ^b	32.40 ^b	18.67 ^a	2.91	0.004
Urinary N	14.02	16.20	14.99	0.50	0.211
N balance	22.16 ^b	16.20 ^b	3.67 ^a	2.95	0.003
<i>Average daily gain in body weight in buffalo calves (kg)</i>					
Initial BW	98.75	98.25	98.33	1.44	0.990
Final BW	136.83	133.08	132.88	3.09	0.864
Average daily gain (104 d)	366.18	334.93	332.26	29.77	0.894

*See footnote of Table 1. Figures with different superscripts in a row differ significantly.

fed pellets containing 35% straw. Grinding, chopping or pelleting had beneficial effects in breaking down the cell wall contents of paddy straw. These physical processes reduced the particle size of the straw thus, providing easy entry to the rumen or access to the rumen microbes for degradation. Generally, in feeding dry cows, paddy straw can be used up to about 50% of the ration. Rations with paddy straw greater than 50% resulted in loss in body weight of the cows (Aquino *et al.* 2020). The daily nitrogen intake, digestible-N and N-retention were similar in buffalo calves fed complete feed pellets containing 25 or 35% paddy straw, but depressed ($P < 0.01$) in animals fed complete feed pellets containing 45% paddy straw, mainly because of the low

Table 3. Effect of feeding paddy straw based complete feed pellets on the VFA production and energetic efficiency in the rumen of buffalo calves

Constituent	CFP-25*	CFP-35	CFP-45	PSE	p value
TVFA	7.07 ^{ab}	7.94 ^b	6.54 ^a	0.21	0.016
Acetate	4.55 ^{ab}	5.01 ^b	4.12 ^a	0.14	0.024
Propionate	1.42 ^{ab}	1.59 ^b	1.26 ^a	0.05	0.023
Butyrate	0.71	0.87	0.75	0.03	0.055
Isovalerate	0.26 ^a	0.29 ^b	0.26 ^a	0.01	0.012
<i>Energetic efficiency of VFA utilization in the rumen</i>					
E (%)	74.40	74.46	74.53	0.51	0.794
E ₁ (%)	80.49	80.76	80.78	0.63	0.161
E ₂ (%)	18.86	19.24	19.17	0.26	0.619
HR	34.78	35.55	35.52	0.85	0.639
HC	0.26	0.23	0.23	—	0.090
VFAUI	3.56	3.53	3.58	0.15	0.955
Ferm CH ₄	2.12 ^a	2.28 ^{ab}	2.54 ^b	0.17	0.033
MBM (g)	177.54 ^{ab}	199.28 ^b	164.00 ^a	1.30	0.016

*See footnote of Table 1. E, Efficiency of rumen fermentation; E₁, efficiency of conversion of fermented hexose energy to VFA energy; E₂, efficiency of conversion of fermented hexose energy to methane energy; HR, hydrogen recovery; HC, hydrogen consumed; VFAUI, volatile fatty acid utilization index; MBM, microbial biomass. Figures with different superscripts in a row differ significantly.

DM intake in 45% paddy straw group.

The rumen studies revealed that the total VFAs, acetate, propionate and isovalerate production was the highest in animals fed pellets containing 35% paddy straw, statistically comparable with those fed complete feed pellets containing 25% paddy straw. But these parameters were depressed ($P < 0.05$) in animals fed pellets containing 45% paddy straw as compared to those fed pellets containing 35% straw (Table 3). The energetic efficiency of rumen fermentation (E), efficiency of conversion of fermented hexose energy to VFA (E₁), and efficiency of conversion of fermented hexose energy to methane energy (E₂) were comparable in all the three groups of calves fed complete feed pellets. The hydrogen recovery and hydrogen consumption were also comparable in all the three groups of calves. The fermentable methane emission increased ($P < 0.05$) linearly with the increase in paddy straw level in complete feed pellets. The differences between the animals fed CFP-25 and RSP-35 as well as those fed CFP-35 and CFP-45 were statistically non-significant. But it increased ($P < 0.05$) in animals fed CFP-45 as compared to those fed CFP-25. The microbial biomass synthesis was observed to be the highest ($p < 0.05$) in group of calves fed pellets containing 35% paddy straw and the lowest was observed in those fed pellets containing 45% paddy straw.

The average daily gain was comparable in buffalo calves fed iso-nitrogenous and iso-caloric complete feed pellets containing 25, 35 or 45% paddy straw. Earlier studies revealed that untreated paddy straw supplemented with high protein concentrate mixture or naturally fermented paddy straw with urea (96.5:3.5; moistened to 40% and stacked

for 9 days) supplemented with low protein concentrate mixture in 60:40 ratio were utilized effectively without any adverse effect on nutrient utilization, rumen metabolites, performance and health of male buffalo calves (Kaur *et al.* 2008, Wadhwa *et al.* 2010).

SUMMARY

This study was planned to prepare paddy straw based complete feed pellets and to assess their impact on the performance of buffalo calves. Iso-nitrogenous and iso-caloric complete feed pellets containing 25, 35 and 45% paddy straw, alfalfa hay and concentrate mixtures were prepared. The roughage to concentrate ratio in the pellets was maintained at 65:35. The CP, EE and cell wall contents in all pellets were comparable. The bulk density of complete feed pellets increased ($p < 0.05$) with the increase in paddy straw level. The *in vitro* studies revealed that NGP, true OM digestibility and ME content decreased linearly with the increase in paddy straw level from 25 to 45% in the pellets. The 104 days growth trial on buffalo calves revealed that the daily DM intake, digestibility of most of nutrients and N-retention decreased ($P < 0.05$) linearly with the increase in level of paddy straw in buffalo calves fed complete feed pellets. The rumen studies revealed that total VFAs, acetate, propionate and isovalerate production; and microbial biomass synthesis was the highest in calves fed pellets containing 35% paddy straw, statistically comparable with those fed pellets containing 25% paddy straw. But these parameters were depressed ($P < 0.05$) in animals fed pellets containing 45% paddy straw. It can be concluded that iso-nitrogenous and iso-caloric complete feed pellets containing paddy straw up to 35% can be utilized effectively without affecting the health and performance of buffalo calves.

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