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Effect of feeding wheat and rice straw based complete feed blocks on nutrients utilization, blood biochemical and growth performance in crossbred calves

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ABSTRACT

An experiment was conducted to evaluate the effect of feeding wheat or rice based complete ration as mash or block form on feed intake, nutrient utilization, blood biochemicals and growth in growing crossbred female calves. Wheat and rice straw based complete feeds having different proportion of roughages in mash form were densified into blocks by applying the pressure of 3,000 psi for dwell time of 30 sec in the complete feed block making machine. Physical characteristics like weight, dimension, bulk density, post compression expansion and durability were evaluated. The highest bulk density (562.2 kg/m^3) and the lowest post compression expansion (28.18%) was observed in rice straw (50% inclusion level) based complete feed block. The blocks were denser and durable without any change in nutritional composition, however, rice straw based feed blocks were more durable with less post compression expansion as compared to wheat straw based blocks. Crossbred female calves (24) of 10–12 months age were divided into 4 groups of 6 calves each on the basis of body weight. Calves were fed mash form of 50% wheat (WM_{50}) or rice (RM_{50}) straw whereas corresponding other group was offered compressed complete feed blocks of wheat (WB_{50}) or rice (RB_{50}) straw based diet *ad lib.* and 2 kg green oat. Feeding trial lasted for 90 days. A digestion trial of 7 days duration was conducted to assess nutrient utilization and blood samples of animals were collected on 85th day of the experimental feeding to anlayse blood bio-chemicals. Average daily weight gain and feed conversion efficiency did not differ in crossbred calves of different groups, however, body weight gain and feed intake was higher in calves fed block as compared to mash form of feed. The digestibility of DM, CP, EE and NFE did not differ among the groups. The blood glucose, total protein, albumin and globulin concentrations, and AST and ALT activities were similar among different groups. It is concluded that feeding of complete ration in block form is beneficial in terms of feed intake, nutrient utilization, growth and feed conversion efficiency in growing crossbred female calves.

Key words: Calves, Complete feed block, Nutrient retention, Performance, Rice straw, Wheat straw

Cereal straws are either left in the field or accumulate where the crop is threshed. Storage and transportation of these feed materials are difficult due to low bulk density, which may be uneconomic for small farmers. Compressing straws and stovers to high density blocks after improving the nutritional quality by incorporating deficient nutrients (Preston and Leng 1984) would possibly overcome this difficulty. Blending of roughages and concentrates in proper proportion into complete feed provides all the nutrients required to get optimum production performance. However, feeding of complete feed in mash form may lead to preferential intake of feed ingredients (Ørskov 1988). Complete compressed feed block (CCFB) is a solidified high density blocks comprising forage, concentrate and other supplementary nutrients in desired proportion capable to fulfill nutrient requirements of animals. The CCFB is convenient, economical, multi-nutrient correcting and ready to eat ruminant complete diet (Salem and Nefzaoui 2003) which results into more stable and ideal environment for rumen fermentation to boost the production performance of animals (Verma *et al*. 1996). This technique also provides opportunity for the incorporation of unconventional and agro-industrial byproducts for economical livestock production and also provides cheaper transportation cost of bulky materials from abundant to scarcity areas at farmers door (Kumar *et al*. 2015). Straws from different cereal species (wheat and rice) vary considerably in nutritive value (Kernan *et al*. 1984, Bainton *et al.* 1987). The present study was undertaken to assess the effect of feeding rice and wheat straw based complete feed in mash or block form on nutrient utilization, blood biochemicals and growth performance in crossbred calves.

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MATERIALS AND METHODS

Diet preparation: Rice straw and wheat straw were procured locally and chopped to 2–3 cm. Total mixed rations based on rice or wheat straws and concentrate mixture in different proportions were thoroughly mixed. Concentrate mixture contained crushed maize 35%, wheat bran 10%, deoiled rice bran 15%, groundnut cake 22%, mustard oil cake 10%, molasses 5%, commercial mineral mixture 2% and common salt 1%. R_{50} and R_{60} contained 50 and 60% rice straw in total mixed ration, whereas W_{50} and W_{60} contained 50 and 60% wheat straw in total mixed ration. RW_{50} were formulated by using 30% each of rice straw and wheat straw. Complete feeds in mash form were densified into blocks by applying the pressure of 3,000 psi for dwell time of 30 sec in the complete feed block making machine (horizontal type).

Physical and chemical evaluation of complete feed block: Physical and chemical characteristics of the blocks were evaluated. The bulk density of mash of complete feeds was estimated (Yadav *et al.* 1991). The feed blocks were stored for 48 h to allow complete expansion and then tested for their increase in density, post compression expansion and durability. Post compression expansion (PCE) after 48 h of storage and durability was measured at different time interval of storage (Singh *et al.* 1998).

$$PCE\ (\%) = T_2 - T_1 / T_1 \times 100$$

where, PCE, post compression expansion; T_1, thickness of blocks at maximum compaction; T_2, thickness of blocks at various time interval.

Each block was dropped from a height of 2 m on a concrete floor. The weight of blocks retained after each fall was measured to estimate durability (%). Durability of the prepared feed blocks was tested by the method of Butler and Mc Colly (1959). Nutritional composition of feed ingredients and complete feed blocks was evaluated (AOAC 2000).

Animals and feeding management: The experiment was conducted on 24 healthy crossbred female calves of 10–12 months of age (119.63±12.4 kg body weight) for 90 days. The experimental animals were divided into 4 groups of 6 each of comparable age and body weight. The calves were de-wormed and vaccinated before the start of the experiment and housed in individual stall having cemented concrete floor with provision for individual feeding and watering. All the calves were fed conventionally as per the requirement of Kearl (1982) for adaptation period of 20 days.

Based on physical characteristics, 4 iso-nitrogenous and iso-caloric complete feed blocks having 50% wheat straw and 50% rice straw were used for animal feeding trials. After 15 days adaptation period, the experimental animals of different groups were fed *ad lib.* mash form of wheat straw (WM_{50}) or rice straw (RM_{50}) based diet whereas calves of corresponding other two groups were offered compressed complete feed blocks of wheat straw (WB_{50}) or rice straw (RB_{50}) based diet. In addition, 2 kg green oats was also provided to each calf/day for meeting its vitamin A requirements. The daily feed offered and residue left by each animal was recorded. The animals were weighed for 2 consecutive days before feeding and watering in the morning at the beginning and at fortnightly intervals. The average weight was recorded and the feed conversion ratio was calculated. Performance of animals fed experimental diets was evaluated in terms of growth performance, feed intake, feed conversion efficiency and health status.

Digestion trial and collection of samples: In the last fortnight of the experiment, a digestion trial for 10 days (i.e 3 days adaptation in metabolic cage followed by 7 days of sample collection) was conducted on 4 experimental animals/group to assess nutrient utilization. Daily feed intake and faeces voided were recorded. The air DM of feed, faeces and orts was determined by drying to a constant weight in a forced air oven at 70°C. Dried samples for each day of the 7 days collection were pooled, ground to pass through a 1-mm screen and preserved for chemical analysis. For nitrogen estimation, faeces samples (0.1%) from individual animals were collected every morning in a 500–ml Kjeldahl flask containing 25 ml of concentrated sulfuric acid.

Analyses: The samples of feed, ort and faeces were preserved as per standard protocol and proximate composition of the sample was determined (AOAC 2000). The fibre fraction, neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined by the procedure of Van Soest *et al.* (1991). Calcium was estimated as per Talapatra *et al.* (1940), while phosphorus was determined calorimetrically using molybdovanadate reagent as per AOAC (2000). Blood samples from jugular vein were collected in serum tubes from all animals on 85^{th} day of the experimental feeding. Serum samples were stored at -20°C until biochemical analysis. The serum was analysed for protein (Hiller and Styke 1927), albumin (Doumas *et al.* 1971), glucose (Somogyi 1945), cholesterol, alanine amino transferase (ALT) and aspartate amino transferase (AST) activity (Burtis *et al.* 1999) using standard diagnostic kits. Test of significance between diets using one-way analysis of variance following completely randomised design was done (Snedecor and Cochran 1994).

RESULTS AND DISCUSSION

Physical and chemical characteristics of complete feed blocks: The bulk density of material used for the blocks ranged from 180.64 kg/m^3 (rice straw based) to 192.72 kg/m^3 (wheat straw based). The bulk density after compression in the form of blocks ranged from 484.4 kg/m^3 to 562.6 kg/m^3 for different roughage alone or in combination. Bulk density of rice straw based block was higher (Table 1) than wheat based complete feed block, which is in agreement with Yadav *et al*. (1991) and Das *et al.* (2005). Bulk density of prepared blocks increased 2.61 to 3.12 times than loose storage of feed ingredients. Yadav *et al*. (1991) reported higher increase in bulk density of rice straw (2.70) as compared to wheat straw (2.5). Sihag *et al.* (1994) observed 2.4 to 3.83 times increase in bulk density of wheat straw based complete feeds. Whereas, Hozhabri and Singhal

Table 1. Physical and chemical characteristics of complete feed blocks

Attributes	R_{50}	R_{60}	RW_{50}	W_{50}	W_{60}	Rice straw	Wheat straw	Green Oat	Concentrate mixture
Physical characteristics									
Block weight (kg)	$1.06^{a}\pm0.01$	$1.05^{a}\pm0.02$	1.04 ± 0.02	1.04 ± 0.03	$1.03^{b}\pm0.02$				
Dimension in cm (L×B× H)	$11.5\times11.6\times13.36^{\mathbf{a}}\pm0.04$	$11.5\times11.6\times13.54^{\mathbf{a}}\pm0.04$	$11.5\times11.6\times13.82^{\mathbf{a}}\pm0.04$	$11.5\times11.6\times14.42^{\mathbf{b}}\pm0.05$	$11.5\times11.6\times14.54^{\mathbf{b}}\pm0.05$				
Mash density (kg m^{-3})	$180.14^{a}\pm2.84$	$171.26^{a}\pm1.28$	$186.84^{a}\pm0.95$	192.72 ± 2.04	185.60 ± 1.28				
Block density (kg m^{-3})	$562.2^{c}\pm9.39$	$528.9\ ^{b}\pm5.84$	$523.6^{b}\pm6.15$	$526.4\ ^{b}\pm15.84$	$484.4\ ^{a}\pm12.8$				
Increase in density	3.12±0.04	3.09±0. 05	2.88±0.12	2.73±0.21	2.61±0. 05				
Durability (%)	$78.83\ ^{b}\pm5.39$	$76.52\ ^{b}\pm1.44$	$74.78\ ^{a}\pm1.08$	$72.79\ ^{a}\pm6.39$	$70.52\ ^{a}\pm1.44$				
Post compression expansion (%)	$28.18\ ^{a}\pm0.92$	$32.79\ ^{b}\pm1.52$	$34.55\ ^{b}\pm2.1$	$35.50\ ^{b}\pm0.85$	$37.79\ ^{c}\pm1.78$				
Nutritional characteristics									
Dry matter	88.25	88.67	88.52	88.33	88.678	89.35	90.94	21.16	90.20
Crude protein	13.26	13.66	13.32	13.60	13.72	3.12	3.06	10.23	20.10
Crude fibre	22.22	23.65	22.98	22.22	25.24	36.34	38.56	36.10	7.88
Ether extract	1.96	1.88	1.92	1.14	1.88	1.24	1.16	1.06	4.62
Nitrogen free extract	48.48	49.66	48.87	45.96	49.66	39.48	44.24	42.98	59.65
Total ash	12.38	9.15	11.03	13.12	9.15	14.98	12.48	9.63	8.33
Calcium	0.96	0.88	0.91	1.03	0.88	0.37	0.26	0.23	1.54
Phosphorus	0.57	0.71	0.60	0.59	0.71	0.13	0.08	0.21	0.56
Neutral detergent fibre (NDF)	59.03	62.28	62.08	58.72	61.90	75.26	74.64	60.80	42.80
Acid detergent fibre (ADF)	38.06	41.33	39.94	38.54	33.53	54.58	49.92	45.60	21.46

[abcd] Values in a row bearing different superscript differ significantly ($P<0.05$).

(2006) observed 4.1 times increase in bulk density of wheat straw based complete feed blocks and higher bulk density in complete feed blocks prepared from sugarcane bagasse than that of wheat straw. Zhang *et al*. (2012) reported high porosity in rice straw. There is a negative linear relationship between the porosity and the bulk density of the straws (Bouasker *et al.* 2014), therefore, higher bulk density of rice straw as compared to wheat straw based complete feed block was observed. Highest weight noticed in rice straw (1.06 kg) based feed blocks could possibly be due to higher bulk density of rice straw based feed block.

Post compression expansion (PCE) was higher in wheat straw than rice straw block based complete feed (Table 1). Samanta *et al.* (2004) and Hozhabri and Singhal (2006) also recorded higher PCE of wheat straw based complete feed than those based on other roughages. Higher PCE in wheat straw based blocks may be attributed to the higher capacity of wheat straw particles to attain their original shape than those of other roughage sources after the removal of pressure (Hozhabri and Singhal 2006). Durability of the blocks ranged from 70.52 to 78.83%. Rice straw based complete feed blocks had significantly (P<0.05) higher durability than other blocks. The negative relation between PCE and durability of feed blocks observed in the present study is in conformity with those of Yadav *et al.* (1991) and Hozhabri and Singhal (2006).

There was no visible change in colour, texture, and no mould growth was noticed during 6 months of storage as reported earlier (Singh *et al*. 1998). Nutritive value of the complete blocks ranged from 13.26 to 13.72% in terms of crude protein. Pressure in the power driven complete feed block machine did not alter the nutrient composition as reported by Verma *et al*. (1996).

Live weight gain and nutrients intake: The body weight gain and average daily body weight gain did not differ (Table 2). Singh *et al.* (2007) and Sharma *et al*. (2010) also noticed higher live weight gain in crossbred calves fed complete feed pellet or blocks compared to conventional feeding system. The feed conversion efficiency among the groups did not differ significantly. Although feed required per unit weight gain was statistically lower for calves fed complete feed blocks (either rice or wheat straw based) compared to those fed mash form indicating that densification improved feed efficiency.

Feeding of complete feed block had significant (P<0.05) effect on the intake of dry matter. Similarly, higher dry matter intake was also observed in crossbred calves (Singh *et al*. 2007) and buffalo calves (Verma *et al*. 1996, Singh *et al.* 1998). Differences in DM intake between mash and block form of complete feed might be due to the physical nature of the feed as well as post ingestion phenomenon (Raghuvansi *et al*. 2007). The calves that were offered block form of feed were unable to make selection and it might have encouraged animals to eat more. Higher feed intake in rice straw based complete feed might be due to differences in physical characteristics of rice and wheat straw. Hogan *et al*. (1986) suggested that animals select plant material on the basis of tenderness.

Nutrient retention: Digestibility coefficients of DM, OM, CP, CF and NFE did not differ significantly (P>0.05) than that of mash form of complete feed (Table 3). This result corroborated the findings of Verma *et al.* (1996) and Sharma *et al.* (2010) in growing buffalo calves and crossbred calves, respectively. Wadhawa and Bakshi (2006) did not find any significant difference in digestibilities of DM, CP, EE, NDF, ADF, cellulose and hemicellulose in buffalo calves fed complete ration over conventional ration. The digestible crude protein (DCP) and total digestible nutrients (TDN) intake did not differ in calves fed either block or mash. Similar results were reported in crossbred calves (Dwivedi *et al*. 2003). Digestibility of nutrients depends on the nature and proportion of roughages in the animal diet

Table 2. Effect of complete feed block on growth performance in calves

Particulars	WM_{50} (mash)	WB_{50} (block)	RM_{50} (mash)	RB_{50} (block)
Initial body weight (kg)	108.50±14.6	109.30±12.4	109.40±20.1	111.3±16.5
Final body weight (kg)	145.98±16.4	148.20±15.0	148.42±8.40	155.61±10.6
Total body weight gain (kg)	37.48^a±6.10	38.90^a±2.94	39.02^a±4.35	44.31^b±6.12
Body weight gain (g/day)	416.45±23.4	432.22±15.62	433.58±20.6	462.38±18.9
Total DM intake (kg/d)	3.34±0.26	3.78±0.17	3.46±0.09	3.88±0.21
DM intake (kg/100kg body weight)	2.62±0.41	2.84±0.28	2.72±0.32	2.95±0.29
DM intake (g/kg $W^{0.75}$)	69.35±7.32	73.81±9.16	71.20±8.34	75.14±9.08
Feed conversion ratio (kg DM consumed/kg weight gain)	8.02±0.94	7.98±0.84	7.98±0.92	7.88±0.78
DCP intake (kg)	0.42±0.03	0.51±0.05	0.45±0.04	0.56±0.06
DCP intake (kg/100kg body weight)	0.33±0.02	0.39±0.01	0.35±0.01	0.41±0.01
DCP intake (g/kg $W^{0.75}$)	8.71^a±0.15	10.06^b±0.11	9.35^a±0.23	10.54^b±0.18
TDN intake (kg)	2.38±1.24	2.52±1.65	2.42±0.92	2.61±1.18
TDN intake (kg/100kg body weight)	1.87±0.13	1.92±0.09	1.90±0.08	1.94±0.12
TDN intake (g/kg $W^{0.75}$)	63.50±2.24	65.15±2.96	64.02±2.68	67.25±1.54

[abcd]Values in a row bearing different superscript differ significantly (P<0.05).

Table 3. Effect of complete feed block on digestibility of nutrients in calves

Particulars	WM_{60} (mash)	W_{60} (block)	RM_{60} (mash)	RB_{60} (block)
Dry matter	52.64±2.11	64.90±2.86	53.90±1.70	56.02±1.54
Organic matter	54.34±3.22	56.12±2.45	55.16±2.56	55.78±2.32
Crude protein	65.20±2.50	66.94±1.96	65.54±2.08	65.86±1.11
Ether extract	63.55±2.62	65.12±.1.42	65.37±1.86	66.32±3.04
Crude fibre	56.62±2.25	56.32±3.24	57.52±2.56	56.36±3.09
Nitrogen free extract	62.9±2.76	63.80±1.15	65.23±2.08	64.36±2.58
Neutral detergent fibre	42.94±1.85	43.72±3.22	43.22±2.94	44.68±3.61
Acid detergent fibre	43.62±2.10	44.62±3.04	46.32±4.14	47.58±3.76

Table 4. Effect of complete feed blocks on blood biochemicals in calves

Particulars	WM_{50} (mash)	WB_{50} (block)	RM_{50} (mash)	RB_{50} (block)
Glucose (mg/d100 ml)	53.59±3.85	53.80±2.95	55.67±3.05	56.80±2.86
Total protein (mg/100 ml)	6.54±0.29	6.45±0.25	6.68±0.46	6.86±0.55
Albumin (mg/100 ml)	3.15±0.05	3.51±0.09	3.98±1.05	3.56±1.02
Globulin (mg/100 ml)	3.08±0.08	2.93±0.16	2.67±0.10	3.40±0.20
Albumin/Globulin ratio	1.03±0.02	1.21±0.02	1.54±0.04	1.06±0.06
Total cholesterol (mg/100 ml)	57.74±2.42	59.86±2.86	54.42±2.10	53.48±2.09
ALT (units/ml serum)	40.94±0.98	43.10±0.86	44.19±1.16	44.80±1.88
AST (units/ml serum)	55.46±1.16	52.41±2.11	54.45±0.78	55.57±1.74

(Cantalapiedra-Hijar *et al.* 2009).

Serum biochemical studies: The values of biochemical constituents in the present study (Table 4) were in the normal range in all the groups (Chauhan 1995). There was no significant difference in serum glucose, total protein, albumin and globulin, total cholesterol, ALT and ALP concentrations among the different groups of crossbred calves (Table 4). Similar results were observed in crossbred calves (Sharma *et al*. 2010).

Densification of rice or wheat straw based complete feed mixture resulted into denser and durable complete feed blocks without any change in nutritional composition. Feeding of complete feed blocks is beneficial in terms of feed intake, body weight gain, nutrients utilization and feed conversion efficiency with normal values of blood biochemicals in growing crossbred calves as compared to feeding complete feed in mash form.

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