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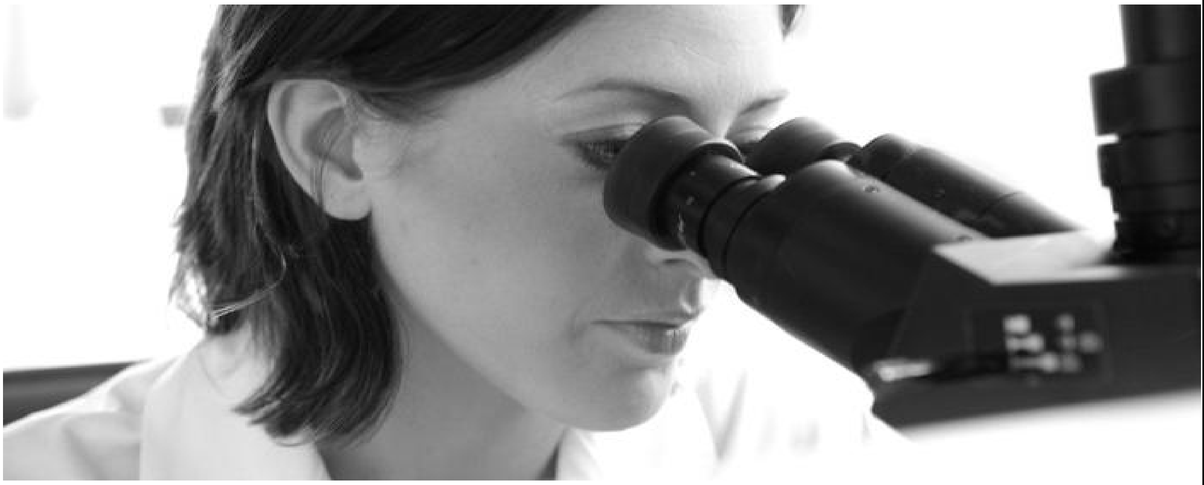

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RESEARCH ARTICLE

USE OF CROP RESIDUES FOR MANUFACTURING COMPOUND PELLET FEED FOR CATTLE

Khandaker ZH[1]., Uddin MJ[2]* and Ara Z[1]

[1]Department of Animal Nutrition, Bangladesh Agricultural University, Mymensingh, Bangladesh
[2]Department of Animal Nutrition, Sylhet Agricultural University, Sylhet, Bangladesh

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ABSTRACT

Stall feeding of ruminant is challenging due to shortage and/or supply of bulky roughages. Densely populated countries are losing both pasture and arable land and thereby feeding of ruminants are subjected to crop residue. In this vulnerable situation, alternative techniques of feeding are emerging need. Keeping this view, effective use of crop residues (straw and bagasse) were taken to produce compound pellet feed. Three types of straw pellet and bagasse pellets were prepared with the combination of concentrate feed at 60:40, 50:50 and 40:60 ratio of concentrate and roughage. Straw pellets comprised with a bit higher level of CP than that of bagasse pellet. Conversely, bagasse pellets discharged better energy in *in vitro* gas production technique than straw pellet. Addition of higher rate of concentrate increased significantly availability of digestible nutrients. Moreover, an *in vibo* digestibility trial was conducted to evaluate the nutritive values of compound pellets. T_1, T_2 and T_3 groups of animals were fed straw based pellet, bagasse based pellet and straw with concentrate mixture. Percent digestible nutrients (CP, CF, NFE and EE) and total digestible nutrients (TDN) were found better in straw pellet than that of bagasse pellet. N intake and retention was similar among all the groups but better was in T_1 group. Straw pellet was found more effective than bagasse pellet or conventional straw feeding method.

INTRODUCTION

The digestive tracts of ruminants are structured so that they retain large quantities of forage where microbial fermentation breaks down the fibrous plant material. The nutrients in roughages are made available largely through microbial digestion. The types of roughages used by such animals as a feedstuff are pasture grasses and other grazed forages; hay and dehydrated forages; silage and crop residues and crop industrial by-products. Green forages are usually the cheapest source of feed nutrients required by ruminant animals for growth, body maintenance and milk production. However, green forage supplies are going to be quite limited due to chronological reduction of crop land. Alternative roughage sources are being considered to contribute energy to the diet and fiber for ruminant health. Bangladesh has 22.87 million cattle with 10.0 million lactating animal (3.5 million are crossbred cows). Despite highest cattle densities in Bangladesh (145 large ruminants/km^2), the milk yields are extremely low which is only 200-205 litres/lactation period (Anon, 2008) because of the alarming shortage of green forages. The availability of metabolizable energy (ME) for cattle is only 25.24% with the deficits of 74.76% (Akbar *et al*, 2005). Besides rice straw and maize stover production was 575.0 million tons (considering 250% extraction rate) in 2007-2008 having a growth rate of 62.89% (Khaleduzzaman, 2009). Most of the work done on urea or other chemical treatment of straw improved both intake, digestibility and live weight gain by cattle and sheep (Said, 1981). Other alternatives to treatments are chopping the stover and supplementing them with wheat bran and/or molasses have done but yet not as ready feed. A limited research work already been done in the department of Animal science, BAU (Bostami *et al*. 2008) and BLRI (Sarker *et al* 2007) on compound feed production.

The large quantities of cereal crop residues have been using as fuel in households which could potentially be used as alternative cattle feed for complete feeding (pellet). The digestibility of cane bagasse are limited due to the formation of strong physical and/or chemical bonds between lignin and the structural polysaccharides (cellulose and hemicelluloses) presents in cell walls but could remarkably be increased by processing pellet. However, preparing compound feed with cane bagasse, rice straw and concentrate might be the novel strategy of feeding the cattle to boost up their production, also will reduce the competition of fodder production on crop land. In other hand, this new device will encourage the farmers to rear large animals in stall feeding in very near future. Besides, a well-planned feeding program that includes crop residues or other low cost feeds provides the opportunity to minimize cost

Corresponding author:* **Uddin MJ
Department of Animal Nutrition, Sylhet Agricultural University, Sylhet, Bangladesh

of production. Keeping this view the work was done to determine the nutrient level of crop residues and concentrate feed to formulate and manufacture the compound pellet feed for cattle and to evaluate the nutritional qualities and effective use of pellet.

MATERIALS AND METHODS

Cane begasse was collected from the sugar cane producing area Pabna and Kustia district and other feedstuffs were purchased from local market of Mymensingh district. Crushing/grinding of begasse and rice straw were done with chopper and grinder machine at Shahjalal field lab, department of Animal Nutrition, BAU, Mymensing. Locally made Horizontal Mixer machine and Pellet machine were also used at field lab. Chemical analyses of feed stuffs were done at Animal Nutrition analytical laboratory using the methods of AOAC (2006). Besides, nutritive values of six category pellets were evaluated by using *in vitro* (Menke *et al*. 1979) technique. In vitro fermentation trial, rumen fluid was obtained from rumen fistulated native bull just before the morning feeding. The rumen liquor was transported into insulated pre-warmed flask under anaerobic condition from field lab to analytical lab. The fluid was pooled in equal proportions before its use as a source of inoculum. The buffer solution was prepared as described by McDougall (1948) according to the formula for synthetic saliva. It was prepared by dissolving 9.8g $NaHCO_3$, 9.3g $NaHPO_4 12H_2O$, 0.47g NaCl, 0.57g KCl, 0.04 $CaCl_2$ (anhydrous) and $MgCl_2$ (anhydrous) per liter distilled water maintaining pH 7-8. After returning from the field lab, collected rumen liquor was stained through cheese cloth into pre-warmed flasks, while CO_2 was flushed into the flask to remove air from rumen fluid. The flask was screw capped immediately and kept at 38-39^{0}C in a water bath. The rumen fluid was mixed with the pre-warmed buffer a 1:4 ratio by mixing 1 part of rumen fluid and 4 parts of buffer solution. Feed ingredients and prepared compound pellet samples were incubated into 100 ml of glass tubes having 200mg of sample in each tube. Then it was filled up with rumen mother culture (rumen liquor mixed with buffer) up to 30 ml of maintaining anaerobic condition subsequently. The tubes were sealed with silicon sibs. And thereafter the tubes were placed on the shelf of automatic rotating water bath at 39^{0}C. After 12 and 24 hours produced gas was recorded and finally the tubes were collected from water bath and measured the gas production volume and were also recorded. Finally, using gas volume, the DOM, DE and ME were measured.

Two types of compound feed were manufactured as Straw Pellets (SP_1, SP_2 and SP_3) maintaining straw and concentrate ratio 40:60, 50:50, 60:40 respectively. Bagasse Pellets (BP_1, BP_2 and BP_3) were also made alike the straw pellet regarding bagasse and concentrate proportion. (Cane begasse and concentrate ratio 40:60, 50:50, 60:40). Concentrate combination were 50, 25 and 25 % of MOC, broken maize and rice polish for all categories of straw and bagasse pellets. In both cases 10% molasses and 1% salt were incorporated as pellet binder, readily fermentable energy, appetizer and maintain acid base balance as well.

Figure 1 Feed ingredients and mixing

Figure 2 Cattle pelleting and physical examination

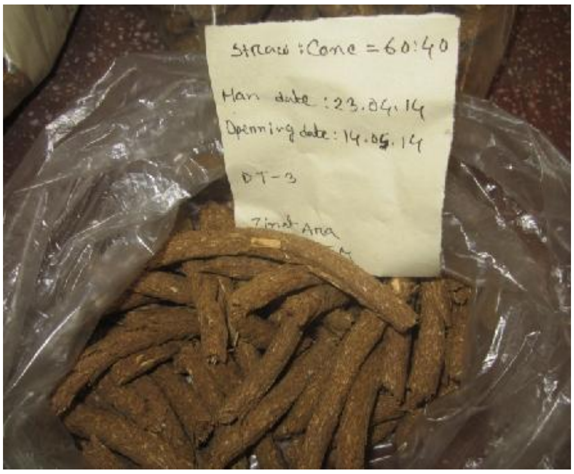
Table 1 Proximate components of ingredients used in compound pellet preparation

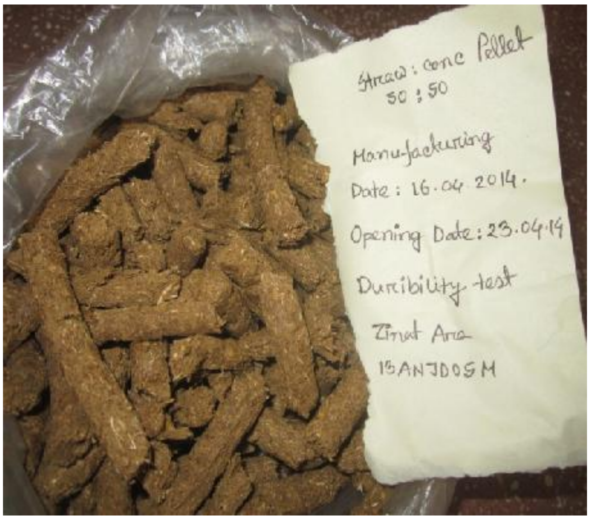
Feed ingredients	Nutrients					
	DM	**CP**	**CF**	**NFE**	**EE**	**TA**
Crushed maize	88.9	9.49	2.72	2.36	1.69	74.25
Rice Polish	93.13	9.025	20.805	10.08	19.3	31.765
MOC	91.19	33.73	7.75	8.3	10.225	6.265
Rice straw	92.2	4.15	31.83	4.64	2.02	35.21
Sugarcane bagasse	93.07	2.24	37.845	3.69	3.04	50.945
Molasses	74.37	5.23	-	0.05	12.055	77.435

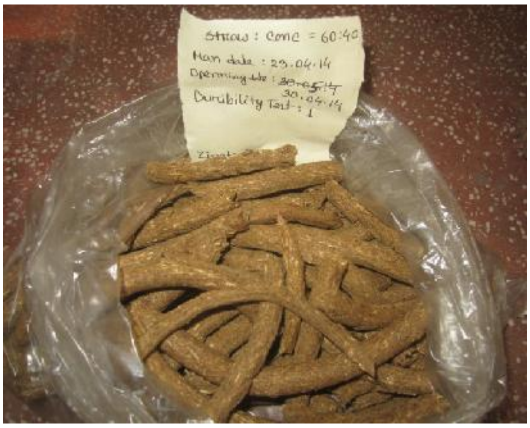
DM=Dry matter, CP=Crude protein, CF=Crude fiber, NFE=Nitrogen free extract, EE=Ether extract, TA=Total ash

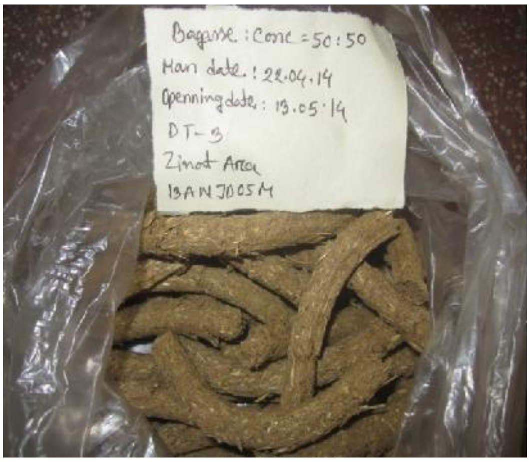
RESULTS AND DISCUSSION

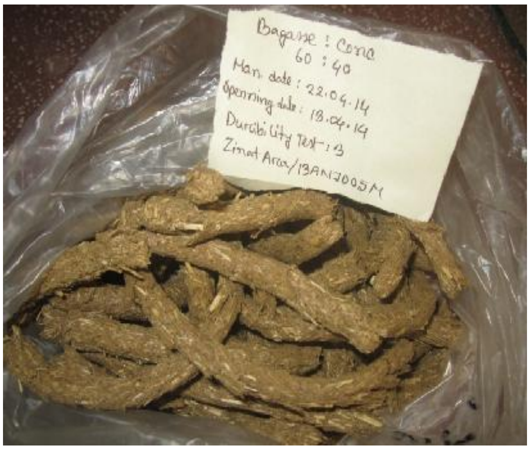
The nutrient content of formulated six compound pellet feed is exhibited in table 2. The DM content of all sorts of complete feed was with in 91 to 92%. Straw pellet 1, 2 and 3 comprised with 40:60, 50:50 and 60:40 ratio of straw and concentrate feed contained statistically different amount of crude protein at 1% level. Straw pellet-1(SP1) contained significantly higher CP rather than SP2 and SP3. The reason of variation was very clear that addition of more concentrate increased the CP level. On the other hand, for CF containing issue, all the pellets of straw varied significantly ($P<0.01$) and chronologically from SP3 to SP1. Concentration of more straw increased the CF level. The NFE was found higher in more concentrate added group SP1 followed by SP2 and SP3.











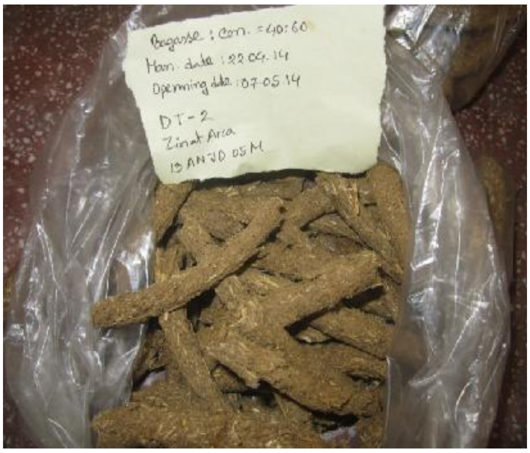


Figure 3 Different forms of straw and bagasse pellets

Table 2 Nutrient level of formulated compound cattle pellet

Feed	Nutrients					
	DM	**CP**	**CF**	**NFE**	**EE**	**TA**
Straw pellet-1	92.61^{a}±0.41	14.26^{a}±0.5	12.99^{c}±0.81	60.37^{a}±0.96	5.8^{a}±0.16	11.12^{b}±0.41
Straw pellet-2	92.6^{a}±0.41	11.44^{b}±0.5	18.03^{a}±0.81	54.74^{b}±0.96	4.28^{b}±0.16	12.32^{a}±0.41
Straw pellet-3	91.48^{b}±0.41	10.71^{b}±0.5	15.71^{b}±0.81	52.3^{c}±0.96	4.02^{b}±0.16	11.92^{ab}±0.41
Bagase pellet-1	91.48^{b}±0.41	13.66^{a}±0.5	15.56^{b}±0.81	56.84^{b}±0.96	4.37^{b}±0.16	9.57^{c}±0.41
Bagase pellet-2	92.07^{ab}±0.41	10.82^{b}±0.5	18.13^{a}±0.81	59.22^{a}±0.96	3.37^{c}±0.16	8.48^{d}±0.41
Bagase pellet-3	92.52^{a}±0.41	10.67^{b}±0.5	18.35a±0.81	59.92^{a}±0.96	3.32^{c}±0.16	7.74^{d}±0.41
Level of sig.	P<0.01	P<0.01	P<0.01	P<0.01	P<0.01	P<0.01

DM=Dry matter, CP=Crude protein, CF=Crude fiber, NFE=Nitrogen free extract, EE=Ether extract, TA=Total ash

Crude fat content of three straw based pellets were found significantly higher in SP1 owing to addition of high level of concentrate than that of SP2 and SP3. Gross minerals was found significantly higher in SP3 type pellet due to high portion of mineral source (straw) part in ration.

Same trend was observed for bagasse based pellets that were also composed of same type and combination of concentrate feed ingredients like straw based pellet. Increasing level of concentrate increased the nutrient level since concentrate rich in nutrient availability rather than roughage. Between straw and bagasse type pellet, there was similarity with the same ratio of roughage and concentrate. DM content was found within 91-92.5% range. In case of CP content, straw based pellets showed higher value than that of bagasse based pellet. It means that straw contained more CP than bagasse (Table 1). On the contrary, bagasse contained more CF and NFE that reflect on bagasse based pellet fermentation and invitro nutritive value analysis. Gross minerals were found significantly higher in straw pellet than that of bsgasse pellet.

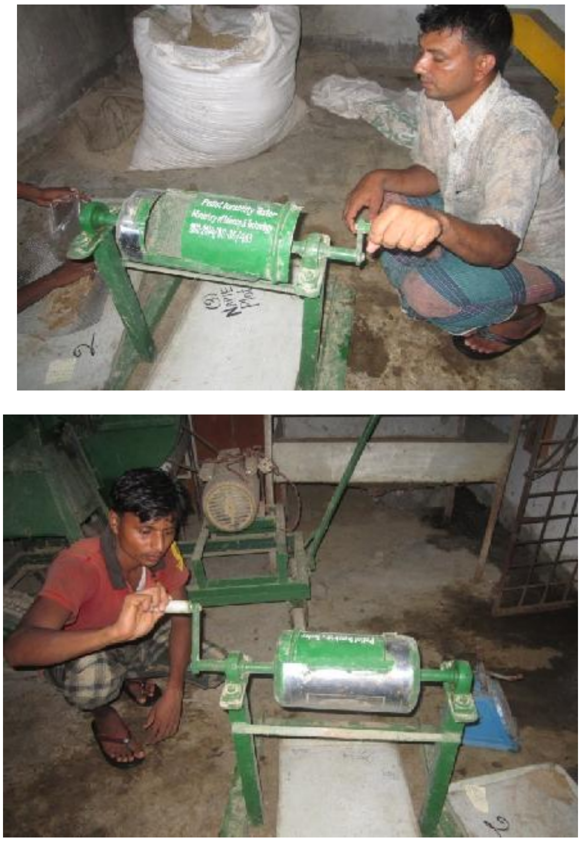


Figure 4 Durability test of cattle compound pellets

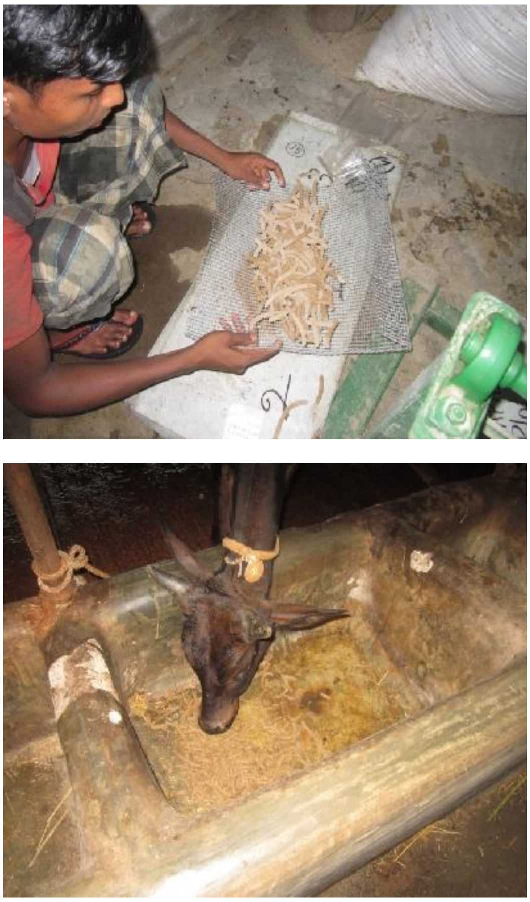


Figure 5 Durability test and cattle feeding of compound pellets

Table 3 Nutritive value of available concentrate used in cattle pellet manufacturing

Feed ingredients	Nutritive value				
	Gas prodn	**%DOM**	**DE(MJ/kg)**	**ME(MJ/kg)**	**%CP**
Maize	70.29^{a}±1.22	81.98^{a}±0.78	14.20^{a} ±0.27	12.55^{a}±0.15	9.52^{b}±0.55
Rice polish	9.64^{c}±1.22	35.58^{c} ±0.78	6.27^{b}±0.27	9.25^{c}±0.15	9.03^{b}±0.55
Mustard oil cake	36.35^{b}±1.22	71.58^{b} ±0.78	13.6^{a}±0.27	10.44^{b}±0.15	33.03^{a}±0.55
Level of significance	P<0.01	P<0.01	P<0.01	P<0.01	P<0.01

DOM=Digestible organic matter, CP=Crude protein, ME=Metabolizable energy, DE=Digestible energy

The nutritive value of concentrate feeds are represented in table 3. Gas production especially methane producing ability was significantly higher for maize grain. Cereal grains are rich in nutrient especially maize for starch that is the limiting factor for microbial biomass production and at the same time fermentation of rumen content. The reflection was observed in OMD of maize that was remarkably higher (P<0.01) than that of MOC (mustard oil cake) and RP (rice polish). MOC, the protein rich concentrate emitted gas half of the maize while RP produced one fourth of MOC that was the significantly lower volume. However, OM digestibility was comparatively better of MOC versus gas production volume. Protein increased the digestibility of feed. The poor value (half of MOC) of OM digestibility may be due to strong lignified bond of cellulose and lignin. Energy value (DE and ME) of kg^{-1}DM feed discharged from maize grain was peak in position than that of MOC and RP. MOC having more crude fat (5 times of maize), emitted the 2nd highest energy. RP produced near about MOC though significantly differed with maize and MOC. RP and maize had the similar CP but MOC uphold more than three times CP of maize/RP.

Table 4 Nutritive value of available crop residue used in cattle pellet manufacturing

Crop residue	Nutritive value				
	Gas prodn	%DOM	DE(MJ/kg)	ME(MJ/kg)	%CP
Straw	6.03^{b}±0.43	33.49^{b}±0.98	5.26^{b}±0.17	3.55^{b}±0.19	4.17^{a}±0.15
Sugarcane bagasse	16.27a±0.43	36.29^{a}±0.98	5.84^{a}±0.17	4.35^{a}±0.19	2.23^{b}±0.15
Level of significance	P<0.01	P<0.01	P<0.01	P<0.01	P<0.01

DOM=Digestible organic matter, CP=Crude protein, ME=Metabolizable energy, DE=Digestible energy

The table 4 depicts the nutritive values of straw and sugarcane bagasse roughages that were used as basal component of cattle compound feed. In fermentation, gas producing ability was significantly (P<0.01) higher in cane bagasse fermentation than that of straw that was also reflected on OM digestibility, energy release MJ kg^{-1} DM. The results of this findings conflect with the statement of Sallam *et al* (2007) statement. They reported that sugarcane bagasse contain large amount of CF, NDF and ADF but low level of in vitro gas production. DSugarcane bagasse could be an interesting alternative animal feed which could be more available in ruminant feeding if its feeding value would be improved. Tewatia and Gupta (1998) stated that the main nutritional constrains of bagasse is slow rate of digestion and low nitrogen content. The CP content was varied significantly between this two roughages. RS was two times better than SB regarding CP content matter. However, it could be concluded that bagasse can be focused as better energy releasing fibrous feed while straw supply more CP.

Table 5 Strength of compound pellet formatted with crop residue and concentrate feed materials

Compound feed	Durability (%)
Straw pellet-1	98
Straw pellet-2	97
Straw pellet-3	96
Bagasse pellet-1	98
Bagasse pellet -2	96
Bagasse pellet-3	94

The durability of ready pellets (Table 5) were tested up to five minutes rotation (200/min) in to locally made rotator. All types of pellets were more than 95% while only bagasse pellet-3 was less rigid to rotation (94%). However, straw pellets were more stable rather than bagasse pellets. Binding ability increased with the increased level of concentrate due to containing more starch and less fiber that helped to bind the shape of pellet.

Table 6 illustrates the quality of straw and bagasse based compound pellet feed. SP1 produced more gas in fermentation than the others due to availability of fermentable carbohydrate. SP1 showed more digestibility than SP2 and SP3 type of feed. This result was the resemble of gas production index. For releasing energy, SP1 also performrd better than that of others. CP content was also found higher in SP1 and followed by SP2 and SP3 respectively. The reason eas very clear that addition of concentrate feed at high magnitude increased the nutritive value and activity of microbes as well as eventually improved the digestibility of feed.

The similar performance were observed for bagasse based pellets as well. However, bagasse pellets were more fermentable than that of straw based pellets. Meanwhile, the straw based pellet uphold the better CP. The extent of cellulose digestion is depended upon its crystallinity and its physic chemical association with other cell wall components like lignin (Chawdhry 1998a). 50g Kg^{-1} DM lignin availability indicate 800g Kg-1 of cellulose may be digested for young pasture but if the lignin increase up to 100g Kg-1 DM, the proportion of cellulose digestion may be less than 600g Kg-1 (Chawdhry 1998a). Cellulose digestion also reduced by increasing the amount of starch (McDonald *et al* 2002). Hemicellulose digestion also related with lignin where increased amount of lignin compounds decreased digestibility of hemicelluloses (Van Soest 1994).

Table 7 depicts the comparison of nutritive value of three types of feeds through digestibility trial. Digestible DM, CP, CF, NFE, EE and TDN were found higher value for T_1 in most of the cases in comparison to T_2. The traditional feeding of cattle (T_3) showed the low nutritive value for TDN, EE and NFE to compare with pellet straw feeding may be due to optimum mixing and pressure while pellet formation. Total nitrogen intake was low in straw pellet fed group but retention was high than that of straw feeding group. The result implies the better nutritive values of processed feed. Meanwhile, bagasse pellet fed group took highest amount of N but showed lower reservation of N to compare with straw pellet fed group. Straw pellet was superior to bagasse pellet may be less lignified bond.

Table 6 In vitro digestibility and nutritive values of different cattle pellet manufactured using crop residues

Feed	Nutritive value				
	Gas prodn	%DOM	DE(MJ/kg)	ME(MJ/kg)	%CP
Straw pellet-1	36.11a±0.93	57.24b±0.77	10.14ab±0.14	8.31a±0.14	14.2b±0.50
Straw pellet-2	35.27ab±0.93	56.12bc±0.77	9.72cd±0.14	7.83b±0.14	11.44b±0.50
Straw pellet-3	29.88c±0.93	54.29d±0.77	9.52de±0.14	7.39c±0.14	10.71b±0.50
Bagasse pellet-1	36.74a±0.93	59.12a±0.77	10.37a±0.14	8.32a±0.14	13.66a±0.50
Bagasse pellet -2	37.16a±0.93	57.76ab±0.77	9.94bc±0.14	8.01ab±0.14	11.01b±0.50
Bagasse pellet-3	33.32b±0.93	54.65cd±0.77	9.36e±0.14	7.4c±0.14	10.72b±0.50
Level of significance	P<0.01	P<0.01	P<0.01	P<0.01	P<0.01

DOM=Digestible organic matter, CP=Crude protein, ME=Metabolizable energy, DE=Digestible energy

Table 7 Digestible nutrients and N retention of pellets

Parameters	Treatments			Level of significance
	T_1	T_2	T_3	
DDM (%)	54.19±2.55	48.52±2.55	48.17±2.55	NS(P=0.09)
DCP(%)	8.07^a±0.39	6.15^b±0.39	8.26^a±0.39	**(P<0.01)
DCF(%)	2.7^b±0.73	12.08^a±0.73	10.75^a±0.73	**(P<0.01)
DNFE(%)	39.99^a±1.06	18.58^b±1.06	15.64^c±1.06	**(P<0.01)
DEE (%)	5.77^a±0.16	5.5^b±0.16	7.22^b±0.16	**(P<0.01)
TDN (%)	63.87^a±2.12	49.28^b±2.12	50.9^b±2.12	**(P<0.01)
NI (g/d)	58.93±5.79	62.34±5.79	61.42±5.79	NS(P=0.83)
N excretion (g/d)	25.08±3.47	29.6±3.47	29.44±3.47	NS(P=0.39)
N balance (g/d)	33.84±3.77	32.74±3.77	31.98±3.77	NS(P=0.87)

T_1=Straw pellet group, **T_2**=Bagasse pellet group, **T_3**=Straw with concentrate group, DDM=Digestible dry matter, DCP=Digestible crude protein, DCF=Digestible crude fiber, DNFE=Digestible nitrogen free extract, DEE=Digestible ether extract, TDN=Total digestible nutrients, N=Nitrogen, NI=Nitrogen intake

CONCLUSION

Complete feeding of ruminant is important in confined and drought season rearing. Healthy feed ensure optimum rumen environment and maximize the production. Roughage based feeding might be improved by the addition of high nutrient density feed. Compound pellet feeding may be the better option for cattle feeding at adverse situation. Moreover, cattle business may be the easy way in confined environment at urban area as well.

Recommendations

This technology might render more valuable and effective information for efficient production of cattle. The relationship of the objectives of the present knowledge lies in the fact that at present the feeding activity in production improvement in feeding the cattle in this country is conventional. But with the findings of this research, the animal could be fed with appropriate amount of crop residues with a remarkable level of nutrition as per their need and release the fodder land for crop production. This might encourage stall feeding system in Bangladesh. Growth trial might be done before final recommendation for commercial production.

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