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Nutrient utilization by Murrah buffaloes (*Bubalus bubalis*) from compressed complete feed blocks

A.K. Verma *, U.R. Mehra, R.S. Dass, A. Singh [1]

Animal Nutrition Division, Indian Veterinary Research Institute, Izatnagar-243 122, U.P., India

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Abstract

Twelve Murrah male buffaloes of 3.5 years age, weighing 370.3 ± 8.41 kg were assigned to three diets in different physical forms with similar ingredient composition comprising of wheat straw, sugarcane molasses, crushed maize, deoiled peanut meal, mineral mixture, sea salt along with vitablend @ 690, 100, 100, 100, 6,4 and 0.2 g kg^{-1}, respectively in a randomized block design. The animals on Diet 1 received wheat straw impregnated with molasses and concentrate mixture separately, while those on Diet 2 were fed the total feed as a complete mix. Diet 3 was offered after moulding complete mix into a compressed complete feed block (CCFB), prepared with the help of indigenously designed and fabricated feed block machine operable on compression technology. A metabolism trial of seven days duration was conducted after 60 days feeding trial in order to assess nutrient utilization and retention as well as plane of nutrition.

The physical form of the diet had no significant influence on nutrient utilization as well as on the digestibility of various nutrients. But feeding of CCFB resulted in a significantly ($P < 0.05$) higher intake of DM and digestible DM and in turn in the intake of all other nutrients as compared to the feeding of diets in other two ways. Though, daily nitrogen retention was not affected, the feeding of CCFB diet resulted in higher ($P < 0.05$) retention of calcium and phosphorus. Thus, CCFB would be a balanced wholesome diet for ruminants. Because of a decrease in the bulk density, the handling, storage and transportation becomes easy and economical. Further, they can be a part of famine feed banks for drought prone regions of developing countries as evolved technology is easy to adapt.

Keywords: Buffalo; Feed blocks

* Corresponding author.

[1] Present address: Department of Agricultural Engineering, Indian Agricultural Research Institute, New Delhi 110 012, India.

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1. Introduction

Seasonal crop residues, such as straws (wheat, *Triticum vulgare*/paddy, *Oryza sativa* L.) and stovers (maize, *Zea mays* L.; sorghum, *Sorghum vulgare* etc.) form staple part of ruminant diet in developing countries (Jayasuriya, 1987). But handling, storage and transportation of these low density (65–70 kg m^{-3}) residues (Yadav et al., 1990) become a major constraint in the feeding of livestock. Compressing straws and stovers to high density (300–500 kg m^{-3}) blocks (Bruhn et al., 1959) after improving the nutritional quality by incorporating deficient nutrients for attaining maximum production from livestock (Preston and Leng, 1984) possibly overcomes this difficulty. Moreover, this technology proves to be a convenient (Neric et al., 1984), economical (Fitt, 1979), medicinal carrying (McBeath et al., 1979), multinutrient correcting (Leng, 1984) and wholesome feeding system for ruminants. In addition to form a part of 'Famine Feed Banks' for successful livestock production programmes for small and marginal farmers, landless labourers and other weaker sections of the society, this compressed complete feed block (CCFB) technology provides a great potential for an efficient utilization of available crop residues and agro-industrial by-products including waste materials as low cost as well as a ready to eat ruminant diet to meet prevailing scarcity conditions which are further aggravated by recurring frequent floods and droughts (Singh and Mehra, 1990) in India and other developing Third World countries. Keeping these facts in view, efforts were made to design and fabricate a feed block manufacturing machine based on compression methodology in collaboration with the Department of Agricultural Engineering, Indian Agricultural Research Institute, Pusa, New Delhi, India. The feed blocks so prepared were subjected to palatability and nutrient utilization studies with male Murrah buffaloes in order to investigate the suitability in ruminant feeding systems.

2. Materials and methods

2.1. Design and working of animal feed block making machine

Efforts were made to develop a manually operated small capacity animal feed block making machine (Fig. 1) based on previous work on briquetting of paddy straw (Singh and Singh, 1982) and wheat straw (Singh and Singh, 1983). The machine consists of a hydraulic ram, power pack, compaction chamber and frame. The compaction chamber is made up of 50 × 50 × 50 mm iron plate, the outlet of which is closed with 50 mm thick plate during compaction. The hydraulic ram that operates with 7.5 hp three phase motor with a stroke of 750 mm results in a block size of 300 × 300 mm. The block size can be adjusted as per requirements and can turn out 100 kg wheat straw h^{-1}. The machine is designed to exert a maximum pressure of 400 kg cm^{-2} sufficient for compressing most of the roughages to a desired specific weight. A moisture content of 8–12% is desirable for optimum binding and sugarcane molasses at the rate of 10–15% can serve as a binder.

The feed mix is manually fed through the feed hopper into the compaction chamber after closing front opening with a 450 × 450 × 50 mm iron plate during the backward

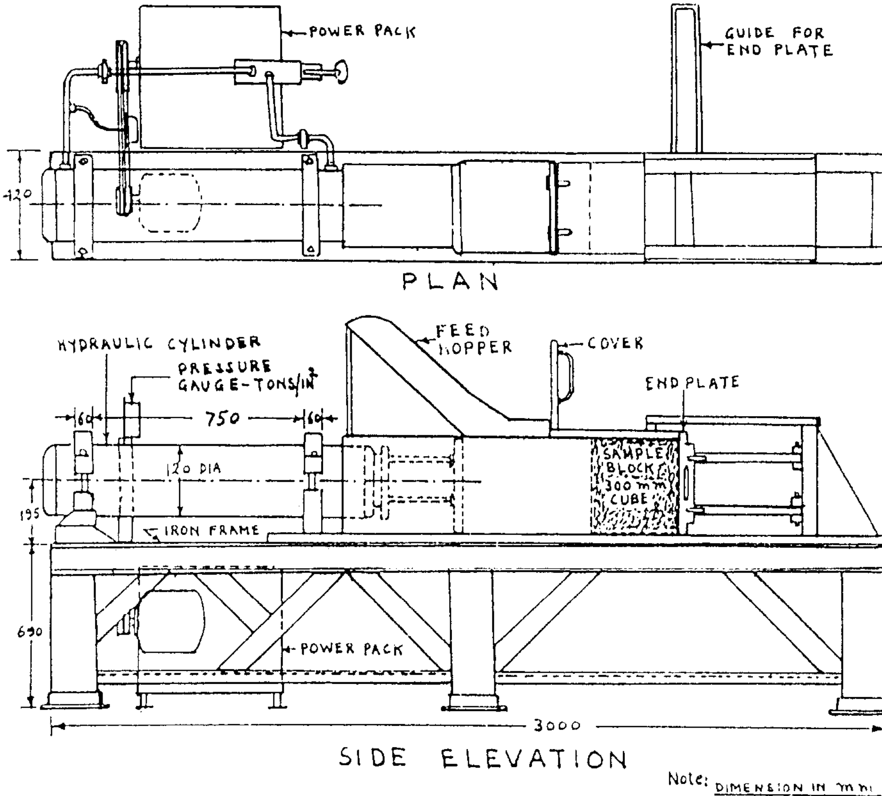

Fig. 1. Animal feed block making machine.

stroke of piston. The forward stroke of the piston with the desired pressure compresses the feed mix. The block is then removed after releasing pressure by removing opening plate with the help of sliding guide attached to the frame by a forward stroke of piston.

2.2. Preparation of CCFB

Suitable quantity (8–8.5 kg) of complete feed mixture consisting of wheat straw, sugarcane molasses, crushed maize, deoiled peanut meal, mineral mixture, sea salt and vitablend (Vitamin A and D_3, 50 000 and 5000 I.U./g, respectively) @ 690, 100, 100, 100, 6, 4 and 0.2 g kg^{-1}, respectively, was fed into compaction chamber of the machine and compressed at 250 kg cm^{-2} pressure to form CCFB which were stored until fed to animals.

2.3. Animals and feeding

Twelve male Murrah buffaloes (*Bubalus bubalis*) of 3.5 years, weighing 370.3 ± 8.41 kg were assigned in equal numbers to three diets with similar and comparable proportion of ingredients namely, wheat straw with molasses and concentrate moiety separately (Diet 1), complete whole mixture in mash form (Diet 2) and CCFB (Diet 3) in a completely randomized design. They were fed individually to meet the maintenance requirements (Kearl, 1982) on respective diets for 60 days duration. The measured quantities of all diets were offered daily at 9.00 a.m. However, wheat straw impregnated with molasses in similar proportions present in rest of the diets was offered to the animals on Diet 1 only after complete consumption of concentrate moiety (equivalent to that present in Diets 2 and 3). The left over residue of each animal was weighed after 24 h consumption to arrive at daily total feed intake. At the end, a seven days metabolism trial involving total quantitative collection of faeces and urine and recording of feed and residues was carried out on all the animals after acclimatizing them in metabolism cages for suitable period to attain uniform intake and output.

2.4. Analyses

The chemical composition of biological samples (feed, faeces and urine) was determined by the methods described by Association of Official Analytical Chemists (AOAC, 1980). The fibre fractions, neutral detergent fibre (NDF) and acid detergent fibre (ADF), were analysed as per Van Soest et al. (1991). Total carbohydrate content of feed and faeces was arrived by subtracting crude protein and ether extract from organic matter. Calcium was estimated as per the method of Talapatra et al. (1940), while phosphorus was determined colorimetrically using molybdovanadate reagent as per AOAC (1980). The data were subjected to test of significance between diets using one-way analysis of variance following completely randomised design as described by Snedecor and Cochran (1980).

3. Results and discussion

3.1. Physical characteristics of CCFB

Reduction in molasses content during manual briquetting adversely affected the compactness of the blocks. On the other hand, even by substantial reduction in the proportion of binder in the form of molasses to 100 g kg^{-1} mass of block from high levels of 290 g kg^{-1} that was used in manual briquetting by Singh and Mehra (1990), the physical structure and compactness was improved as the bulk specific weight of blocks was increased by four times and appears to be transport friendly. Moreover, the altered fermentation pattern and reduced feed consumption observed on high molasses diets (Dass et al., 1987) would be nullified by using low levels of molasses as binder.

3.2. Dietary chemical composition

The chemical composition, fibre fractions, calcium and phosphorus varied closely among CCFB and diet in mash form (Table 1). Subjecting total feed mix to 250 kg cm^{-2} pressure in the power driven compressing machine, therefore, did not alter the nutrient composition.

Table 1
Chemical composition of feedstuffs offered to various groups (per cent on dry matter basis)

Feedstuffs	Organic matter	Crude protein	Ether extract	Totalcarbo-hydrate	NDF	ADF	Calcium	Phos-phorus
Concentrate mixture [a]	90.86	23.59	2.61	64.66	32.02	13.08	1.60	0.60
Wheat straw + molasses [b]	92.06	4.87	1.42	85.77	79.23	48.16	0.62	0.17
Complete feed mix [c]	92.27	8.80	1.62	81.85	71.89	41.26	0.86	0.18
CCFB [d]	92.52	8.84	1.68	82.00	70.40	43.86	0.86	0.18

[a] Used in groups 1, 2 and 3 diets.
[b] Used in groups 1, 2 and 3 diets.
[c] Group 2 diet.
[d] Group 3 diet (CCFB, compressed complete feed block).

3.3. Nutrient digestibility and plane of nutrition

The physical form of the diet greatly influenced the intake of dry matter (DM) as well as other nutrients (Table 2). The animals fed on CCFB consumed significantly ($P < 0.05$) more of both DM as such and digestible DM. This was reflected in the enhanced ($P < 0.05$) intake of organic matter (OM) and total carbohydrates but not crude protein (CP) as such and on digestible nutrient basis. However, increased intake of digestible ether extract (EE) on CCFB diet though did not attain statistical significance, it was higher ($P < 0.05$) on CCFB diet than on Diet 1 and 2 on as such basis. The animals on CCFB also consumed significantly more of NDF ($P < 0.05$) as such and ADF ($P < 0.01$) as such and digestible as compared to those on other two diets. Though the concentrate:roughage ratio of the consumed DM remained similar (1:2.23) among diet of complete mix (Diet 2) and CCFB (Diet 3), the consumption of roughage was lower on diet fed on concentrate and roughage (1:1.86) separately (Diet 1). The increased intake of DM through concentrate, thus compensated by a lowered roughage DM intake on Diet 1. This resulted in comparable intake of DM between animals on Diets 1 and 2. The problem of preferential intake was overcome by moulding the complete mix into block leading to a significantly higher intake on CCFB diet. It was proved beyond doubt that feed (DM) intake increases substantially in animals fed diets in pelleted form (Laredo and Minson, 1975; Reddy and Reddy, 1990) or when fed as feed blocks (El-Khidir and Nadya, 1992) than as complete mash mix or concentrate moiety separately with similar ingredient composition. This might probably be due to limiting of diurnal variations which provides stable rumen ecosystem for optimum and efficient microbial growth and in turn microbial protein synthesis (Reddy et al., 1991) and thus beneficial for normal performance of the animal.

The higher intake of DM and other nutrients on CCFB diet did not influence the digestibility of various nutrients as the digestibilities were comparable among animals on different diets, though a negative correlation exists between intake and digestibility with regards to all the nutrients, while a positive correlation is seen with respect to intake and digestibility of EE (Maynard et al., 1983). They suggested that the depression in digestibilities would be more pronounced only when the intake is three to four times

Table 2
Nutrient digestibility and plane of nutrition in buffaloes fed different diets

Attribute	Diet			SEM
	1	2	3	
Dry matter, through:				
Wheat straw + molasses	4862.5	–	–	
Concentrate mixture	1670.9	–	–	
Loose mix	–	6338.0	–	
Block mix	–	–	7572.1	
Intake (g day^{-1}) *	6533.4 ^{a}	6338.0 ^{a}	7572.1 ^{b}	298.23
Intake (g kg W$^{-0.75}$) **	77.4 ^{a}	75.3 ^{a}	89.5 ^{b}	2.17
Digestible intake (g day^{-1}) *	3724.1 ^{a}	3620.0 ^{a}	4361.7 ^{b}	164.78
Digestibility (%)	57.0	57.0	57.6	0.50
Organic matter				
Intake (g day^{-1}) *	5994.6 ^{a}	5848.1 ^{a}	7005.7 ^{b}	274.92
Digestible intake (g day^{-1}) *	3558.0 ^{a}	3523.2 ^{a}	4256.5 ^{b}	522.10
Digestibility %	59.4	60.2	60.8	0.55
Crude protein				
Intake (g day^{-1})	631.0	557.1	669.4	29.11
Intake (g kg W$^{-0.75}$) **	7.5 ^{ab}	6.6 ^{a}	7.9 ^{b}	0.20
Digestible intake (g day^{-1})	239.0	221.9	265.3	12.23
Digestibility (%)	37.9	39.8	39.7	1.18
Ether extract				
Intake (g day^{-1}) *	112.7 ^{a}	102.7 ^{a}	127.2 ^{b}	5.10
Digestible intake (g day^{-1})	75.0	66.1	79.8	4.65
Digestibility (%)	66.3	64.7	62.6	2.68
Total carbohydrates				
Intake (g day^{-1}) *	5251.0 ^{a}	5187.7 ^{a}	6209.1 ^{b}	241.72
Digestible intake (g day^{-1}) *	3232.9 ^{a}	3234.0 ^{a}	3911.4 ^{b}	151.33
Digestibility (%)	61.6	62.3	63.1	0.54
Neutral detergent fibre				
Intake (g day^{-1}) *	4387.5 ^{a}	4556.4 ^{a}	5330.7 ^{b}	205.90
Digestible intake (g day^{-1})	2636.0	2603.2	3033.1	159.39
Digestibility (%)	55.0	57.1	57.0	0.69
Acid detergent fibre				
Intake (g day^{-1}) **	2560.3 ^{a}	2615.0 ^{a}	3320.6 ^{b}	123.15
Digestible intake (g day^{-1}) **	1155.7 ^{a}	1404.9 ^{a,b}	1681.1 ^{b}	81.06
Digestibility (%)	45.3	53.6	50.5	1.34
Total digestible nutrients (TDN)				
Intake (g day^{-1}) *	3640.6 ^{a}	3604.8 ^{a}	4356.1 ^{b}	1680.3
Intake (g kg W$^{-0.75}$) **	43.1 ^{a}	42.8 ^{a}	51.6 ^{b}	1.27

Means with different superscripts in a row differ significantly: * $P < 0.05$; ** $P < 0.01$.

higher than that of maintenance requirements, which was not the case with CCFB diet in the present study. Moreover 20% higher intake of molasses on this diet might have resulted in preferential attack by rumen microbes compensating the depression in digestibility. At the same time it is interesting to note that intake of highly digestible concentrate moiety was almost same between Diets 1 and 3 culminating in similar digestibilities. The increased intake of various digestible nutrients including digestible fibre fraction and nitrogen (g CP kg W$^{-0.75}$) on CCFB diet was indicative of optimum

Table 3
Mean daily retention (g day^{-1}) of various nutrients

Attribute	Diet			SEM
	1	2	3	
Intake and balance of nutrients (g day^{-1})				
Nitrogen				
Intake	101.0	89.1	107.1	4.66
Faecal excretion	62.7	53.7	64.7	3.29
Urinary excretion	25.7	24.5	28.5	1.93
Balance	12.6	11.0	14.0	1.21
Calcium				
Intake *	56.9 ^{a,b}	54.5 ^{a}	65.1 ^{b}	2.65
Faecal excretion	50.8	44.9	56.6	3.26
Urinary excretion **	0.8 ^{a}	2.4 ^{b}	2.1 ^{b}	0.17
Balance	5.3	7.2	6.4	1.31
Phosphorus				
Intake *	8.0 ^{b,c}	6.3 ^{a}	7.6 ^{b}	0.30
Faecal excretion	4.2	3.5	4.2	1.37
Urinary excretion	0.9	0.4	0.4	1.58
Balance	2.9	2.5	3.0	1.43

Means with different superscripts in a row differ significantly: * $P < 0.05$; ** $P < 0.01$.

availability of energy and fermentable nitrogen for the growth of rumen cellulolytic microorganisms (Kunju, 1986; Tiwari et al., 1990) as supported by significantly ($P < 0.01$) higher total digestible nutrient (TDN) intake on this diet. However, the intake of both protein (CP) and energy (TDN) was respectively higher by 10.0 and 6.3% on CCFB diet than the stipulated requirements of Kearl (1982), while the intake of these nutrients was lower than the standards on other two diets.

3.4. Nutrient retention

Though the animals on all the three diets were in positive nitrogen (N) balance, the increasing level of nitrogen intake, especially on CCFB diet, led to higher daily retention by these animals in accordance with the earlier reports of Lofgreen and Loosli (1947). However, the daily retention on this diet did not attain statistical significance because of insignificantly higher faecal as well as urinary-N losses (Table 3). However, Sivaiah (1979) did not notice any effect in faecal-N loss due to dietary protein and energy levels, but urinary-N excretion in his studies with buffaloes was found to be more when dietary-N levels increased.

Because of higher DM intake by animals fed CCFB, there was significantly ($P < 0.05$) more consumption of Ca and P as compared to those on other two diets despite similar dietary concentrations of these nutrients. But this did not influence the daily retention (dietary Ca:P ratio essentially remained similar across the diets) as they were comparable among animals on all the three diets which were in positive Ca and P balance (Table 3). This clearly indicates that moulding the whole feed mix into a block would not disturb the nutrient retention.

4. Conclusion

Complete feed mix in the form of CCFB, therefore, appears to be wholesome and readily acceptable to buffaloes. Moreover, since the block density is increased by four times, the handling, storage and transportation becomes easy and economical. The CCFB can form a part of 'Famine Feed Banks' in drought prone regions of developing countries to combat malnutrition of livestock during such periods as the evolved technology is easy to adapt under farmers' field conditions.

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