Effect of Graded Levels of Rice Mill Feed (RMF) Supplementation on Intake, Nutrient Digestibility, Microbial N Yield and Growth Rate of Native (*Bos Indicus*) Bulls Fed Rice Straw Alone

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ABSTRACT : Rice bran commonly available in Bangladesh is a mixture of rice hulls (60%), bran (35%) and polishing (5%), referred here as rice mill feed (RMF). Dose response effect of RMF supplementation to a straw diet including a zero level was measured on the intake, digestibility, nitrogen balance, microbial N yield and growth rate of growing native (*Bos indicus*) bulls. Twelve bulls of 33 months old and 272 ± 31.5 kg weight were randomly allocated to diets having 0 (T1), 1 (T2) and 2 (T3) kg RMF in addition to 200 g wheat bran, 200 g molasses, 60 g salt and 30 g oyestershell powder. Concentrate intake was 5.5, 19.2 and 29.5% of the dietary intake for the T1, T2 and T3 treatment respectively.

RMF supplementation had no significant effect on the straw DM intake. However, with the increasing levels of RMF supplementation, total DM & digestible OM intake and the whole gut digestibilities of DM, OM, N & ADF increased but in deminishig return.

Total microbial N yield estimated from the urinary purine excretion were 15.35, 26.56 and 38.44 g/d for the treatment T1, T2 and T3 respectively. Both the N intake and the N balance increased linearly in response to increasing level of RMF. Supplementation of RMF linearly increased the energy intake and dietary energy concentration. Growth rate in the T1, T2 and T3 treatments were 112, 125 and 250 g/d respctively. The basal N excretion and the maintenance energy requirement of the experimental animals were estimated to be 615 mg/kg $W^{0.75}$/d and 447 kJ/kg $W^{0.75}$/d respectively. The estimated efficiency on N utilization was 0.83 mg/mg of N intake ($r^2=0.997$) while the efficiency of metabolizable energy utilization for growth was 0.15. Since animal refused higher levels of RMF, inclusion up to 2 kg level (about 25% of the total DM intake) appears to have no depressing effect on the performances of animal. However, RMF itself fail to meet the critical nutrient need of the rumen microbes. Therefore response of supplementing RMF after correcting the critical nutrient deficiency need to be studied.

(**Key Words:** Rice Mill Feed (RMF), Rice Straw, Microbial N Balance and Growth Rate.

INTRODUCTION

The smallholder mixed farming system dominates the agricultural production system in most of the tropical and sub-tropical regions of the world (Umunna et al. 1995), and specially in South-East Asia where rice-based crop-livestock integration is well established (Preston 1995). In a typical small-holder farm in Bangladesh, approximately 90% of the cattle feed supply is from poor quality roughages, mostly of rice straw and small quantity of green grass with little (appx. 10%) concentrate (Tareque and Sadullah, 1988). Of the available concentrates, approximately 60% comes from rice bran (RB). Rice bran is the outer coarse coat (pericard) and the rice polishing (RP) is the inner bran of grain separated from a series of shellers after the husk is removed (Muller, 1986). Rice husk is the outer covering of paddy and is mostly unsuitable for livestock feeding (Muller, 1986). Rice polishing is relatively rich in protein (amino acids), lipid and starch, which are the critical nutrients that need to be absorbed where the basal feed is digested solely by rumen fermentation (Preston and Leng, 1987). Rice polishing with a large proportion of broken rice grain and oil (12%) found to increase the post-ruminal supply of dietary starch, protein and microbial N yield in direct proportion to the amount of RP in the diet of cattle (Elliott et al., 1978). Similar observations were also reported by other workers (Creek et al., 1976 and Lopez et al., 1976). However, practical experience shows that in Bangladesh, inclusion of high levels of RB in the diet often reduces the milk yield or growth rate in cattle. This is probably because

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the available RB is a mixture of rice hulls (60%), bran (35%) and polishing (5%), therefore, accroding to Gohl (1993), should be referred as rice mill feed (RMF). In the present trial, 'dose response' effect of RMF supplementation to a straw diet including a zero level were measured on the intake, digestibility, nitrogen balance, microbial N yield and growth rate of growing native (*Bos indicus*) bulls.

MATERIALS AND METHODS

Experimental design, animals and diet

This trial was conducted for five weeks during the September, 1995. Twelve indigenous growing bulls of 272 ± 31.5 kg live weight and approximately 33 months old, were randomly allocated to three treatments in a completely randomized design. Originally it was planned to use three levels, e.g., 0, 2 or 3 kg of RMF. However animal refused to eat more than 2 kg RMF. Thus the three treatments were 0 (T1), 1 (T2) and 2 (T3) kg rice mill feed (RMF) to an *ad libitum* chopped rice straw (15 cm) diet. Besides, the individual animal also received 60 g salt and 30 g oyster-shell powder as mineral supplements. Even then, the experimental animals refused to eat the RMF-mineral mixture as it was. Therefore, to increase the palatability all the three groups received 200 g wheat bran, 200 g molasses in addition to the RMF-mineral mixture. The concentrate mixture was offered twice (08:00 and 17:00 hour) by mixing with water. The straw was offered throughout the day 15% in excess of the requirement. The RMF was finely ground and was collected from the local market. The rice straw was of unknown high yielding variety, cultivated during the winter months, collected from the central-north region of Bangladesh. The chemical composition of different feed ingredients are shown in table 1. The animals were housed in face-out-stanchion-barn during the 1st 4 weeks. On 5th week, digestibility and N balance measurements were in metabolic stalls having facilities for separate collection of faeces and urine.

Live weight change

Animals were weighed weekly before the morning feed. Live weight changes were measured from the differences between the initial and final live weights.

Chemical analysis

Samples of feeds, refusals and faeces were analysed for dry matter (DM), organic matter (OM) and N according to AOAC (1984). Urinary N also measures in the same way. The acid detergent fibre (ADF) was determined according to Goering and van Soest (1970). The urine samples were analysed for determining purine derivatives (allanton + 15% correction for uric acid) and the microbial protein absorbed in the intestine was estimated from the knowledge of the purine : protein ratio in microbial biomass, (Chen and Gomes, 1992).

Statistical analysis

The data were analysed by an ANOVA of completely randomized design with appropriate standard error of mean differences. Simple linear regression of the form $Y = a + bX$ was used where appropriate. Statistical method of Snedecor and Cochran (1967) was used for the analysis.

RESULTS

Chemical composition

Chemical composition of different feed ingredients are shown in table 1. Organic matter (OM), nitrogen (N) and acid detergent fibre (ADF) content of rice straw were 80, 0.80 and 39 per cent respectively. Compared to that of the wheat bran, RMF had lower (89 *vs.* 94.5%) level of OM and higher (43.5% *vs.* 15%) level of ADF content.

Intake

Intake of straw, concentrate, total DM and OM are presented in table 2. The concentrate level constituted 5.5, 19.2 and 29.5% of the total DM intake (DMI) for the treatments T1, T2 and T3 respectively. Supplementation of RMF increased both total DM and digestible OM (DOM) intake but with diminishing return (see figure 1). However, Straw DM intake slightly reduced (not significant) from 79 to 77 and 74 g/kg $W^{0.75}$/d respectively for the 0, 1 and 2 kg RMF supplementation. The fitted regression between the level of dietary concentrate (X ; % of total DMI) and the straw DM intake (Y ; g/kg $W^{0.75}$/d) are shown in the Eqn. 1.

$$Y = 80 - 0.205X \ (r^2 = 0.96 ; P = 0.125) \ .... \ (\text{Eqn. } 1)$$

Digestibility

Whole gut digestibilities of different nutrients are shown in table 3 and figure 2. Digestibilities of DM, N and ADF increased significantly ($p < 0.01$) with 1 kg RMF supplementation which improved (not significant) further with 2 kg RMF but with diminishing return (figure 2). Organic matter digestibility increased ($p < 0.05$) from 49 to 62% with 1 kg RMF supplementation which remain unchanged (63%) with 2 kg RMF supplementation.

Table 1. Chemical composition (%) of feed ingredients used in the trial

Ingredients	Dry matter (g/100 g of fresh matter)	g/100 g of Dry matter		
		Organic matter	Nitrogen	ADF
Rice straw	88.50	79.95	0.80	39.41
Rice bran	91.64	88.75	2.75	43.50
Wheat Bran	87.97	94.29	2.58	14.77
Cane Molasses	65.00	95.40	0.91	–

Table 2. Dry matter intake (DMI) and organic matter intake (OMI) from straw and concentrate by native bulls fed straw with small amount of concentrate (T1) or T1 supplemented with 1 kg (T2) or 2 kg (T3) of rice bran (RB) daily

Parameters	T1	T2	T3	SED (Residual $df = 9$)	Significance
Total DMI (kg/d)	5.60[c]	6.36[b]	7.24[a]	0.069	$p < 0.01$
Straw DMI (kg/d)	5.30[a]	5.14[b]	5.10[b]	0.069	$p < 0.05$
Wheat Bran DMI (kg/d)	0.18	0.18	0.18	–	–
Molasses DMI (kg/d)	0.13	0.13	0.13	–	–
RB DMI (kg/d)	–	0.91	1.82	–	–
Concentrate DMI (kg/d)	0.31	1.22	2.13	–	–
Straw DMI (g/kg $W^{0.75}$/d)	79	77	74	4.36	NS
Total DMI (g/kg $W^{0.75}$/d)	83[b]	101[a]	106[a]	5.17	$p < 0.05$
Total dig. OMI (g/kg $W^{0.75}$/d)	33[b]	51[a]	55[a]	4.377	$p < 0.05$
RB as % of total DMI	–	14.3	25.1	–	–
Total concentrate as % of live weight	5.5	19.2	29.5	–	–
Substitution rate (%)	–	3.25	3.68	–	–

Table 3. Nutrient digestibility (%) of different groups of growing native bulls fed straw with small amount of concentrate (T1) or T1 supplemented with 1 kg (T2) or 2 kg (T3) of rice bran (RB) daily

Parameters	T1	T2	T3	SED (Residual $df = 9$)	Significance
Dry matter	44[b]	56[a]	58[a]	3.15	$p < 0.01$
Organic matter	49[b]	62[a]	63[a]	3.53	$p < 0.05$
Nitrogen	19[b]	49[a]	53[a]	7.35	$p < 0.01$
Acid detergent fibre	52[b]	62[a]	67[a]	2.76	$p < 0.01$

Table 4. Nitrogen utilization of different groups of growing bulls fed straw with small amount of concentrate (T1) or T1 supplemented with 1 kg (T2) or 2 kg (T3) of rice bran (RB) daily

Parameters	T1	T2	T3	SED (Residual $df = 9$)	Significance
Feed N intake (g/d)	48[c]	72[b]	96[a]	0.58	$p < 0.01$
Faecal N excretion (g/d)	39	40	46	5.88	*NS*
Urinary N excretion (g/d)	11.28	12.15	14.14	2.341	*NS*
Total N excretion (g/d)	50.28	52.15	60.14	6.195	*NS*
N balance (g/d)	−2.05[c]	19.67[b]	37.06[a]	5.85	$p < 0.05$
N balance (mg/kg $W^{0.75}$/d)	−30[c]	295[b]	546[a]	96.9	$p < 0.05$

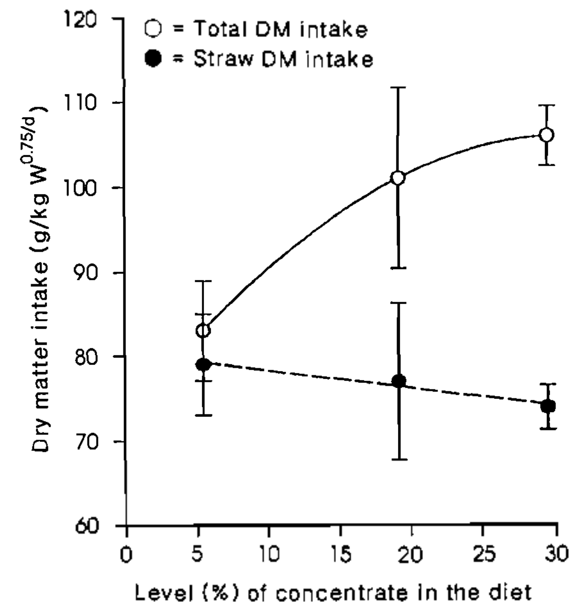

Figure 1. Effect of different levels of rice mill feed supplementation on a straw diet on the total (○) and straw (●) dry matter intake of native growing *Bos indicus* bull. Each point represent the mean of four observations with vertical bar as the standard deviation.

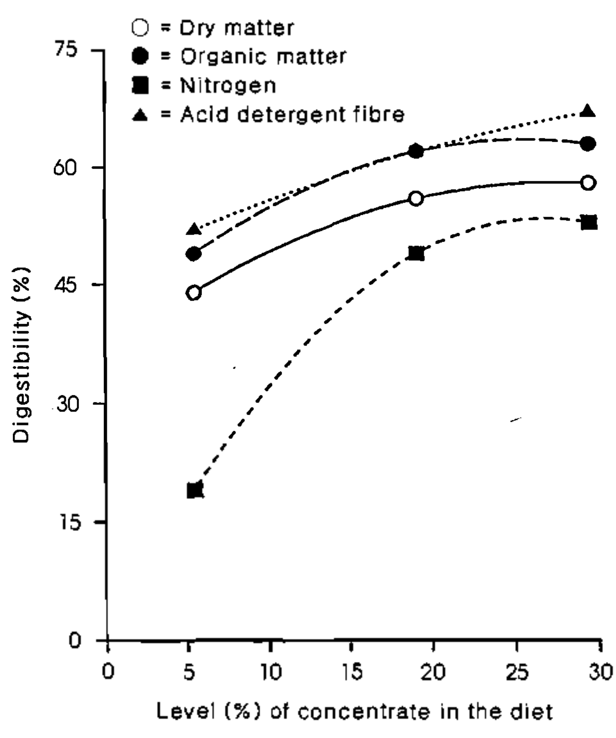

Figure 2. Effect of different levels of rice mill feed supplementation on a straw diet on the whole gut digestibilities of dry matter (○), organic matter (●), N (▲), and acid detergent fibre (■) of native growing *Bos indicus* bull. Each point represent the mean of four observations.

N utilization

Nitrogen utilization by different groups of animals are shown in table 4. Dietary N increased significantly ($p < 0.01$) with the increasing levels of RMF. The fitted regression (see figure 3) between the level of concentrate (X; % of total DM intake) and the dietary N intake (Y; $mg/kg^{0.75}/d$) is presented in Eqn. 2. The incremental increase in N intake per unit of concentrate level was about 29 mg/kg $W^{0.75}/d$.

$$Y = 28.8X + 547\ ;\ (r = 0.998\ ;\ p < 0.05)\ ...\ (Eqn.\ 2)$$

However, the faecal and the urinary N excretion increased only slightly (not significant) in response to increasing levels of RMF. N balance increased significantly ($p < 0.05$) with the increasing levels of RMF. The fitted regression (see figure 3) between the level of contentrate (X; % of total DM intake) and the N balance (Y; mg/kg $W^{0.75}/d$) is presented in the Eqn. 3.

$$Y = 23.95X - 162.62\ (r = 0.999;\ p < 0.01)\ ...\ (Eqn.\ 3)$$

When the N intake (X, mg/kg $W^{0.75}/d$) was regressed (see figure 4) against the N balance (Y, mg/kg $W^{0.75}/d$), the

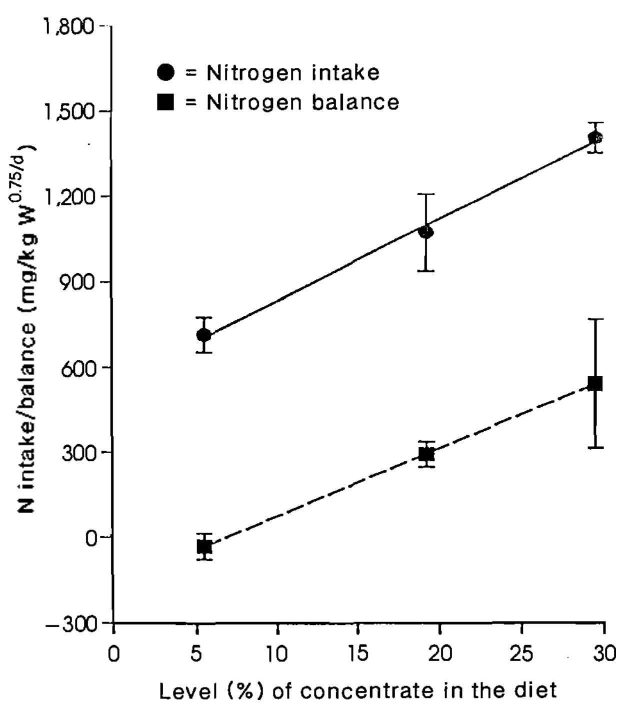

Figure 3. Effect of different levels of rice mill feed supplementation on a straw diet on the total N intake (●) and N balance (■) of native growing *Bos indicus* bull. Each point represent the mean of four observations with vertical bar as the standard deviation.

incremental increase in N balance found to be 0.828 mg/kg $W^{0.75}$/d per mg of N intake and the N excretion at zero N nitake was 615 mg/kg $W^{0.75}$/d.

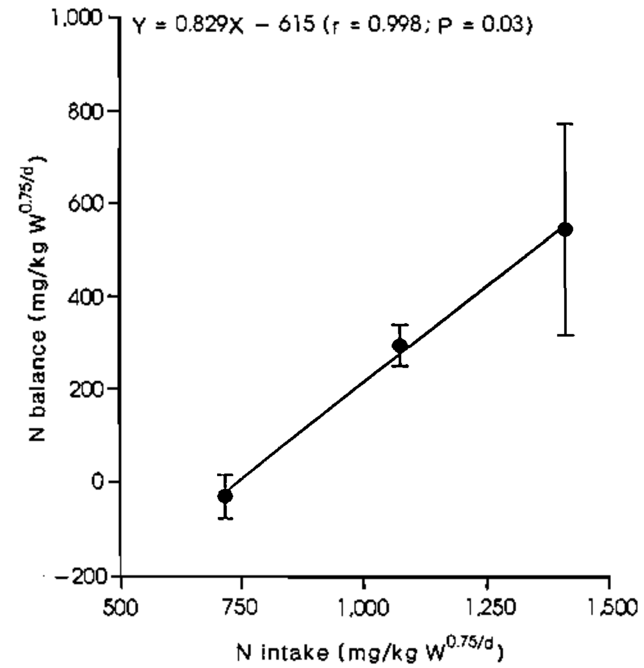

Figure 4. Effect of N intake on the N balance of native growing *Bos indicus* bull fed rice straw supplemented with different levels of rice mill feed. Each point represent the mean of four observations with vertical bar as the standard deviation.

Microbial N yield

The microbial N (MN) yield in different treatments are shown in table 5 and figure 5. Urinary purine derivatives and hence the MN yield increased significantly ($p < 0.05$) with the increasing levels of RMF supplementation. At 5.5, 12.9 and 29.5 percent of dietary concentrate intake, MN yield were 15.35, 26.56 and 38.44 g/d respectively. Regression between the dietary concentrate level and the total MN yield g/d (Eqn. 4) or MN yield g/kg DOMR (Eqn. 5) are as follow.

$Y = 9.54 + 0.95X$ ($r^2 = 0.997$; $P = 0.06$) ... (Eqn. 4)
$Y = 5.83 + 0.15X$ ($r^2 = 0.936$; $P = 0.16$) ... (Eqn. 5)

Here, X = Con. Intake as % of DM intake and Y = Total MN yield g/d (for Equ. 4) or MN yield g/kg DOMR (for Eqn. 5).

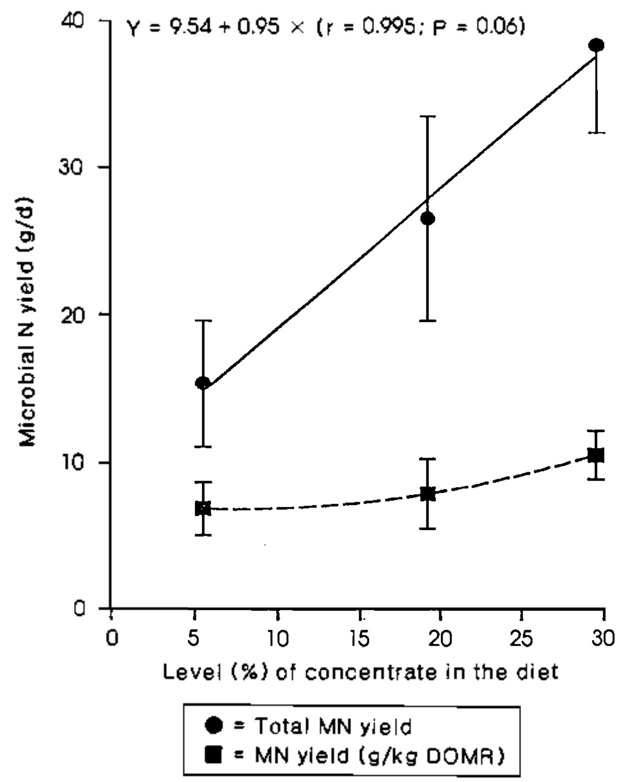

Figure 5. Effect of different levels of rice mill feed supplementation on a straw diet on the total microbial N yield (●) and microbial N g/kg DOMR (■) of native growing *Bos indicus* bull. Each point represent the mean of four observations with vertical bar as the standard deviation.

Energy intake

The metabolizable energy intake (MEI) estimated from the DOM intake as kg DOMI × 15.58 (ARC, 1980), are presented in table 6. At. 5.5, 19.2 and 29.5% of dietary concentrate levels, the estimated MEI were 515,

Table 5. Microbial N yield of different groups of growing bulls fed straw with small amount of concentrate (T1) or T1 supplemented with 1 kg (T2) or 2 kg (T3) of rice bran (RB) daily

Parameters	T1	T2	T3	SED	Significance
Purine Excretion (mmol/d)[§]	21.11[c]	36.53[b]	52.87[a]	5.345	$p < 0.05$
Microbial N yield	15.35[c]	25.56[b]	38.44[a]	3.884	$p < 0.05$
Microbial N yield (g/kg DOMR)[¶]	6.89[b]	8.17[ab]	10.57[a]	1.397	$p < 0.05$

§ Estimated from the urinary allantoin excretion plus 15% allowance for uric acid excretion.
¶ Digestible organic matter apparently fermented in the rumen (DOM × 0.65 = DOMR; ARC, 1980).

Table 6. Energy utilization of different groups of growing bulls fed straw with small amount of concentrate (T1) or (T1) supplemented with 1 kg (T2) or 2 kg (T3) of rice bran (RB) daily

Parameters	T1	T2	T3	SED (Residual *df* = 9)	Significance
DOM intake (kg/d)§	2.221^b	3.408^a	3.747^a	0.2765	$P < 0.05$
ME intake (MJ/d)	34.56^b	53.02^a	58.20^a	4.44	$P < 0.05$
MEI KJ/kg $W^{0.75}$/d	515^b	785^a	850^a	67.9	$P < 0.05$
MEI/MEm¶	1.14	1.74	1.89	–	–
M/D (MJ/kg DM)§	6.17	8.36	8.04	–	–

¶ Assuming metabolizable energy for maintenance is 450 kJ/kg $W^{0.75}$/d (ARC, 1980).
§ assuming 1 kg DOM = 15.58 MJ ME (ARC, 1980).

Table 7. Growth rate and feed conversion efficiency of different groups of growing bulls fed straw with small amount of concentrate (T1) or T1 supplemented with 1 kg (T2) or 2 kg (T3) or rice bran (RB) daily

Parameters	T1	T2	T3	SED (Residual *df* = 9)	Significance
Mean Initial Weight (kg)	272.5	272.3	272.3	24.62	NS
Mean Final Weight (kg)	276.5	276.8	281.3	26.34	NS
Live weight gain (g/d)	112	125	250	99.82	NS
Feed conversion ratio (kg feed/kg gain)	50	51	29	–	–

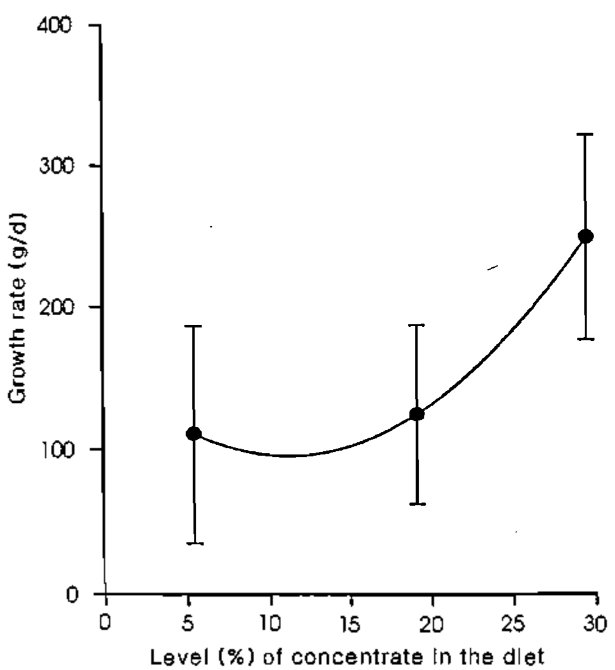

Figure 6. Effect of different levels of rice mill feed supplementation on a straw diet on the growth rate of native growing *Bos indicus* bull. Each point represent the mean of four observations with vertical bar as the standard deviation.

785 and 850 kg/kg $W^{0.75}$/d respectively. The dietary energy concentration (M/D) at 0, 1 and 2 kg RMF supplementation were 6.17, 8.36 and 8.04 MJ/kg DM. Assuming the maintenance ME (MEm) requirement of 450 kJ/kg $W^{0.75}$/d (ARC, 1980), the ratio of MEI to MEm were 1.14, 1.74 and 1.89 respectively for 0, 1 and 2 kg RMF supplementation.

Growth rate

The growth rate of different groups of animals are shown in table 7. Animals on T1 group with 5.5% dietary concentrate (diet without RMF) had a growth rate of 112 g/d, which increased only to 125 g/d (not significant) with 1 kg additional RMF (group, T2). However, a relatively higher growth rate (250 g/d) was observed with 2 kg RMF supplementation (group T3). DM intake for 1 kg live weight gain in T1, T2 and T3 were 50, 51 and 29 kg respectively.

DISCUSSION

Inclusion of rice mill by-products e.g., rice bran, rice polish etc. reported to increase the growth rate, milk production (Preston and Leng, 1987). In the present trial, on a straw diet, the effect of low levels of RMF supplementation on the intake, digestibility, N balance, MN yield and growth rate were studied on growing native bulls.

The ADF content of RMF (44%) was much higher than that of rice bran (10%; Cheva-Israkul and Cheva-Israkul, 1986). This is probably due to high levels of rice hulls (62%; Gohl, 1993) in the former. ADF content is negatively correlated with the OM digestibility (McDonald et al. 1988), which may be the reason why higher levels of RMF often reported (Muller, 1986) to cause depression in the digestiblity. With the increasing levels of RMF supplementation, total DM and digestible OM intake increased curvilinearly while the straw DM intake decreased slightly. Positive associative effects of concentrate (Prasad etal., 1993) or *Leucaena* foliage (Chowdhury and Huque, 1996 Unpublished) supplementation up to 20% of the dietary DM intake have been reported.

Schiere and Wilt (1995) suggested a model where intake of basal diet increases with low quality feed and lower levels of supplementation with nutrients which are limiting. In the present trial, rumen degradable N (RDN) supply from straw (assuming 55% of the straw N is degraded in the rumen, Walli et al., 1993) and concentrate (assuming 70% of the concentrate N is degraded in the rumen, Walli et al., 1993) for the T1, T2 and T3 were 26.62, 43.39 and 60.83 g/d while the corresponding requirements [RDN requirement (g/d) = 1.25 × ME intake (MJ/d); ARC, 1980] were 43, 66.3 and 72.75 g/d respectively. Thus, all the three treatments had deficient supply of soluble N for the rumen microbes which may have depressed the microbial fermentation of straw and thus reduced the straw DM intake despite lower (< 30%) level of concentrate supplementation.

As the ratio of concentrate to straw DM intake increased, digestibilities of DM, OM, N and ADF also increased but in diminishing return. Dixon (1986) proposed that with increasing proportions of highly digestible concentrate to a roughage of low digestibility, there would be a linear increase in DM digestibility in proportion to the amout concentrate. For example, digestibilities of DM increased linearly with the increasing amount of wheat bran supplementation (Chowdhury, 1996). One possible reason for the observed diminishing return of digestibilitites at higher level of RMF could be that there would be higher amounts of rice hulls with higher level of RMF, which depresses the digestibilities due to higher ADF (44%) and silica content (8%, K. S. Huque, Bangladesh Livestock Research Institure, Savar, Dhaka, Bangladesh, Personal communication). Besides, RMF also contain 10-12% fat (Gohl, 1993) which can be 'toxic' to celluloyltic organism in the rumen (El Hag and Miller, 1972) or can 'protect' fibre from fermentation (Harfoof, et al., 1974). Therefore, as far as nutrient digestibility is concerned, the optimum RMF level would probably be between 20-30% of the total DMI.

Although N intake in all three levels of RMF were much higher than the suggested maintenance N requirement of 400 mg/kg $W^{0.75}$/d (ARC, 1984), but the NB at 0 RMF was −30 mg/kg $W^{0.75}$/d. On such a diet, most of the absorbed amino acid N are of microbial origin. The calculated (assuming the amino acid content of microbial N of 0.8, digestibility of amino acids of microbial origin of 0.85 and the utilization efficiency of microbial amino acids of 0.8; ARC, 1984) available microbial amino acid N at the tissue level for the T1 was 124 mg/kg $W^{0.75}$/d, while the estimated (from the regression between N intake and N balance, figure 4) basal N excretion was 615 mg/kg $W^{0.75}$/d. Thus negative N balance can be expected. Relatively higher BNE in the present trial were also observed for both *Bos indicus* (638 mg/kg $W^{0.75}$/d; Chowdhury, 1996, unpublished) and *Bos torus* (641 mg/kg $W^{0.75}$/d l; Ørskov et al., 1983) bulls.

The efficiency of N utilzation, which is the increase in N balance per unit increase in N intake, was 0.83 mg per mg of N intake/kg $W^{0.75}$/d (see the regression between N intake and N balance, figure 4). This value was much higher than the value reported (McDonald et al., 1988) for non-ruminants (0.55) and ruminants (0.40). However, during insufficient protein but adequate energy intake, the efficiency of N utilization in sheep (Black and Griffiths, 1975) and pigs (Campbell, 1987), found to be over 0.80. This may suggest that in the present trial, despite very high levels of N (717 to 1,412 mg/kg $W^{0.75}$/d) and energy (515 to 850 kJ ME/kg $W^{0.75}$/d) intake, the actual amount of amino acid N availability at the tissue level was probably very low, resulting a very high efficiency of N utilization. Increasing levels of RMF probably increased the N availability at the tissue level both from rumen undegradable dietary N and microbial N, which might have resulted linear increase in NB. With the levels of supplement used, there was no threshold level of RMF which showed any exponential (Leng, 1995) or quadratic (Balch, 1967) response for N balance.

With a very small amount of concentrate (200 g wheat bran and 200 g molasses, about 6% of the DM intake) supplement, the MN yield in the present trial was about 7 g/kg DOMR, which is slightly better than the value observed on an absolute straw fed animals of 5 g/kg DOMR by Chowdhury and Huque (1995) or 6 g/kg DOMR by Chowdhury, (1996). Although increasing levels of RMF linearly increased both total MN yield (g/d) and the efficiency of MN yield (i. e., MN yield g/kg DOMR), but the slope was much more steeper for the former (b = 0.95) than the later (b = 0.15). Similar lower efficiency of MN yield was also observed when straw fed growing *Bos indicus* bulls were supplemented with increasing levels of wheat bran (Chowdhury, 1996) or leucaena foliage (Chowdhury and Huque, 1996). One possible reason for marginal response of the efficiency of microbial N yield to increasing levels of supplement could be that the supplied concentrate failed to meet the critical nutrients need of the rumen microbes of which NH_3 (Goodchild and McMeniman, 1994), S (Elliott and Armstrong, 1982), branched chain fatty acids (Ndlovu and Buchanan Smith, 1987), and peptides (Cotta and Hespell, 1986) are the possible candidates. For example, in the present trial, estimated RDN supply were only 45, 35 and 26% of the required level for T1, T2 and T3 treatments respectively.

As expected with the increase in the dietary RMF levels, both total energy intake and the dietary energy concentration also increased. Regression between the growth rate g/d (X) and the ME intake kJ/kg $W^{0.75}$/d (Y) is shown in Eqn. 6.

$$Y = 447(\pm 176.3) + 1.66\ (\pm 1.631)X;\ (r^2 = 0.51;\ n = 3;\ P = 0.495) \quad \text{(Eqn. 6)}$$

From the equation, heat production at zero body weight gain/loss, i. e., the maintenance ME (MEm), was 447($\pm$ 176.3) kJ/kg $W^{0.75}$/d. Similar estimate for straw fed native growing *Bos indicus* bulls were 385($\pm$ 102.2) kJ/kg $W^{0.75}$/d (Chowdhury, 1996). With such large coefficient of variations for the two estimates (39 and 26% for the former and the later respectively), it is difficult exert any degree of confidence on the estimates although the values falls within the range of 400-570 kJ/kg $W^{0.75}$/d of MEm for cattle (ARC, 1980).

In estimating the efficiency of ME utilization, total ME intake MJ/d (X) was regressed against the ME stored as liveweight gain (assuming 34 MJ ME/kg weight gain; ARC, 1980) MJ/d (Y). The regression is presented in Eqn. 7.

$$Y = 0.152X - 1.88;\ (r^2 = 0.53;\ n = 3;\ P = 0.479) \quad \text{(Eqn. 7)}$$

The efficiency of ME utilization for live weight gain was very low (0.15) compared to that of the suggested range of 0.30 - 0.60 (Ferrel, 1988). The efficiency of ME utilization depends on energy concentration, metabolizability of the diet, quality and quantity of protein in the diet and the stage of maturity of the animal (ARC, 1980; Kearl, 1982; McDonald et al., 1988). On straw diet with such fibrous concentrate used in the trial, lower efficiency was probably due to lower glucogenic to acetogenic ratio of the absorbed nutrients (Leng, 1990).

Despite a significant increase in the ME and the N intake, marked, growth response was observed when concentrate intake reached 29.5% of the diet. On a low quality basal diet (e. g., straw) diet, lower levels (< 20% of the DMI, approximately up to 1 kg/d) of supplementation of energy (Coleman et al., 1976) or protein (Poppi and McLennan, 1995; Leng, 1995) concentrate reported to cause linear increase in the growth rate. For example, on sugar cane tops based diet, the growth rate *Zebu* bulls linearly increased with the supplementation of rice polish at a level of 0 - 15% of the dietary dry matter (Preston et al., 1976). It is obvious that as the level of concentrate increased, post ruminal out flow of starch, protein and microbial N both from dietary and microbial sources also increased. However, the supply of nutrients was probably not sufficient enough until 2 kg RMF supplementation to support a moderate growth.

Up to 2 kg level, depressing effect of RMF supplementation was only observed on the digestibilities of different nutrients, while such effect was not observed on other parameters, e. g., MN yield, NB and growth rate. Since animal refuses higher levels of RMF, on a straw diet, inclusion up to 2 kg level (about 25% of the total DM intake) may be recommended for feeding. However, RMF itself fail to meet the critical nutrient need of the rumen microbes. Therefore, response of supplementing RMF after correcting the critical nutrient deficiency need to be studied.

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