Effect of Molasses or Rice Gruel Inclusion to Urea Supplemented Rice Straw on Its Intake, Nutrient Digestibilities, Microbial N Yield, N Balance and Growth Rate of Native (*Bos indicus*) Growing Bulls

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ABSTRACT : The possibility of using rice gruel compared to that of the cane molasses as a source of readily fermentable energy for a urea supplemented straw diet has been studied. Twelve native growing bulls of 237 ± 8.7 kg live weight and 35 months old were randomly allocated to three treatments fed solely rice straw enriched with: (1) 3% urea (US), (2)3% urea + 15% molasses (UMS) and (3) 3% urea + 30% rice gruel (UGS). The feeding trial continued for sixty days. Organic matter (OM) intake was significantly ($p < 0.05$) higher in the UMS (64 g/kg $W^{0.75}$/d) followed by UGS (53 g/kg $W^{0.75}$/d) and US (49 g/kg $W^{0.75}$/d). Estimated (from digestible OM intake) metabolizable energy (ME) intake were 396, 348 and 301 kJ/kg $W^{0.75}$/d for UMS, UGS and US respectively. The maintenance (i.e., no change in live weight) ME intake calculated to be 308 ± 7.4 kJ/kg $W^{0.75}$/d. Urinary purine derivatives excretion was nonsignificantly higher in the UMS (51.73 mmol/d), followed by UGS (42.53 mmol/d) and US (35.26 mmol/d). The estimated microbial N (MN) yield were 21.10, 14.00 and 11.60 g/d for UMS, UGS and US respectively. For each MJ increase in ME intake, MN yield increased by 1.29 ± 0.134g. Observed live weight changes during the experimental period were 292, 125 and −19 g/d respectively for UMS, UGS and US. It was concluded that supplementation of readily fermentable N (urea) alone was not enough to optimize the rumen function and a source of readily fermentable energy was required. Rice gruel was less effective than molasses as fermentable energy source to remove a restriction on voluntary intake and provide less amino acids of microbial origin for absorption from the small intestine, Thus more substrate for protein synthesis and gluconeogenesis were available for growth in the molasses than the rice gruel supplemented animals. However, in situation where molasses is not available or costly, rice gruel does appear to have a place as readily fermentable energy source on a urea supplemented straw diet.

(Key Words: Rice Straw, Molasses, Rice Gruel, Urea, Intake, Microbial N Yield, Growth Rate)

INTRODUCTION

Rice straw is the main energy source for ruminants comprising over 60% of the dietary energy supply in Bangladesh (Jackson, 1981). Works in our laboratory on the supplementation of rice straw with graded levels of common grasses (Chowdhury and Huque, unpublished), *Leucaena* foliage (Chowdhury and Huque, unpublished), wheat bran (Chowdhury, unpublished) or rice mill feed (Chowdhury, unpulished), clearly demonstrated that the lower level of readily fermentable N and energy for the rumen and volatile fatty acids and amino acids for the animal provided by the rice straw are primary limitations to ruminant produciton in this country. On a straw diet, supply of urea (3% of straw) to maintain high levels of rumen ammonia (> 200 mg NH_3-N/litre) and molasses (15% of straw) to provide readily fermentable energy, reported to increase the intake, the rate and extent of digestion and the microbial protein yield relative to VFA production (Huque and Talukder, 1995; Huque and Chowdhury, 1995). However, due to poor distribution channel and high cost, it is not always possible to use molasses as a source of fermentable energy every where in the country. Supplementation with grain or other high energy concentrates is impractical under Bangladesh condition. However, almost every household in the country produces considerable amounts of rice gruel, which is produced during the cocking of rice, containing considerable amounts of soluble starch material. Traditionally, rice gruel is being used in the cattle diet as a drink with water. It could be a good source of fermentable energy when impregnated with straw for the rumen microbes. The present trial has been designed to

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investigate the possibility of using rice gruel compared to that of the cane molasses as a source of readily fermentable energy for a urea supplemented straw diet and its effect on intake, nutrient digestibilities, microbial N yield , N balance and growth rate of native (*Bos indicus*) growing bulls.

MATERIALS AND METHODS

Experimental design, animals and diet

The experiment was continued for sixty days during the period of September to October, 1995. Twelve native (*Bos indicus*) growing bulls of 35 months old and 273 ± 8.7 kg live weight were randomly allocated to three treatments in a completely randomized design. The three treatments were *ad libitum* chopped rice straw supplemented (on dry matter basis) with: (1) 3% urea (US), (2) 3% urea + 15% molasses (UMS) and (3) 3% urea + 30% rice gruel (UGS). Rice gruel was collected daily from a nearby kitchen of security personnel of the Bangladesh Livestock Research Institute. Different combination of straw were prepared daily prior to morning meal and fed throughout the day 15% in excess of animal's intake. The refused straw was collected and weighed in the next morning. Chemical composition of different types of straw are shown in table 1. Animals were housed in a face-out-stanchion barn throughout the experimental period except during the digestibility trial, when they were moved to metabolic stalls, where faeces and urine were collected separately for five days.

Table 1. Chemical composition of molasses, rice gruel and different combinations of rice straw used in the trial

Items	Dry matter (g/100 g of fresh sample)	g/100 g of dry matter		
		Organic matter	Nitrogen	ADF
Rice gruel	4.20	99.88	0.68	–
Molasses	75.99	77.34	0.82	–
Urea-molasses straw	57.65	87.05	1.63	47.40
Urea-rice gruel straw	46.24	87.52	1.92	46.28
Urea-straw	43.02	87.72	1.88	47.80

Liveweight change

Animals were weighed weekly before morning feed. Live weight changes were measured from the differences between the mean (three consecutive days) of initial and final live weights.

Chemical composition

Samples of feeds, refusals and faeces were analyzed for dry matter (DM), organic matter (OM) and nitrogen (N) according to AOAC (1984). Urinary N also measured in the same way. The acid detergent fiber (ADF) was measured according to Goering and van Soest (1970). The urine samples were analysed for determining purine derivatives (allantoin + 15% correction for uric acid) and the microbial protein absorbed in the intestine, was estimated from the knowledge of 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. Statistical methods of Snedecor and Cochran (1967) was used for the analysis.

RESULTS

Intake

Intake of DM and OM are shown in table 2. Straw

Table 2. Dry matter (DM) and organic matter (OM) intake by native growing bulls fed urea-molasses-straw (UMS), urea-rice gruel straw (UGS) or urea-straw (US)

Parameters	UMS	UGS	US	SED (*Residual df* = 9)	Significance
Total DM intake (kg/d)	5.11^{a}	3.98^{b}	3.80^{b}	0.126	$p < 0.01$
DM intake as % of live weight (kg)	1.77^{a}	1.47^{b}	1.39^{b}	0.136	$p < 0.01$
DM intake (g/kg $W^{0.75}$/d)	73^{a}	60^{b}	57^{b}	4.23	$p < 0.01$
OM intake (g/kg $W^{0.75}$/d)	64^{a}	53^{b}	49^{b}	3.41	$p < 0.01$

^{a,b} Values with different superscripts in the same row differ significantly.

DM intake was significantly ($p < 0.01$) higher in UMS (73 g/kg $W^{0.75}$/d) than UGS (60 g/kg $W^{0.75}$/d) and US (57 g/kg $W^{0.75}$/d). Similarly, OM intake was also significantly ($p < 0.01$) higher in UMS (64 g/kg $W^{0.75}$/d) followed by UGS (53 g/kg $W^{0.75}$/d) and Us (49 g/kg $W^{0.75}$/d).

Digestibilities

Digestibilities of different nutrients are shown in table 3. DM and OM digestibilities of UMS, UGS and US fed animals were very similar. No significant difference was observed in N digestibility between UGS and US. Nitrogen digestibility was the highest ($p < 0.05$) in UGS (76%) followed by US (60%) and UMS (55%). ADF digestibility was significantly ($p < 0.05$) higher in US (79%) than UMS (51%) and UGS (45%).

Table 3. Digestibilities (%) of dry matter (DM), organic matter (OM), nitrogen (N) and acid detergent fibre (ADF) by native growing bulls fed urea-molasses-straw (UMS), urea-rice gruel straw (UGS) or urea-straw (US)

Nutrients	UMS	UGS	US	SED (*Residual df = 9*)	Significance
DM	36	37	35	7.95	NS
OM	40	41	39	7.20	NS
N	55^{b}	76^{a}	60^{ab}	9.23	$p < 0.05$
ADF	51^{b}	45^{b}	79^{a}	7.01	$p < 0.05$

^{a,b} Values with different superscripts in the same row differ significantly.

Microbial N yield

Microbial N (MN) yield by animls fed UMS, UGS and US are shown in table 4. Urinary purine derivatives (allantoin and uric acid) excretion was significantly ($p < 0.05$) higher in UMS (51.73 mmol/d) than UGS (42.53 mmol/d) and US (35.26 mmol/d). The estimated MN yield and the efficiency of microbial N production followed the same pattern but the differences was not significant in the later. Daily MN yield for UMS, UGS and US werr 21.1, 14.0 and 11.60 g respectively.

Nitrogen utilization

Nitrogen utilization by different groups of animals are shown in table 5. Total N intake was significantly ($p < 0.05$) higher in the UMS (83 g/d) followed by UGS (75 g/d) and US (65 g/d). However, the N intake was not significant when expressed on metabolic body weight basis. Urinary N excretion followed a reverse pattern with the highest in US followed by UGS and UMS($p < 0.05$). N balance was the highest in UMS (260 mg/kg $W^{0.75}$/d) followed by UGS (227 mg/kg $W^{0.75}$/d) and US (94 mg/kg $W^{0.75}$/d).

Energy intake

The metabolizable energy intake was estimated from the digestible OM (DOM) intake; DOM (kg) × 15.56 (ARC, 1980). Estimated energy intake by different groups of animlas are shown in table 6. Digestible organic matter intake (kg/d) was nonsignificantly higher in the UMS (1.776

Table 4. Microbial nitrogen yield by native growing bulls fed urea-molasses-straw (UMS), urea-rice gruel straw (UGS) or urea-straw (US)

Parameters	UMS	UGS	US	SED (*Residual df* = 9)	Significance
Purine derivatives excretion (mmol/d)[¶]	51.73^{a}	42.53^{ab}	35.26^{b}	4.752	$p < 0.05$
Microbial N yield (g/d)	21.10^{a}	14.00^{ab}	11.6^{b}	3.728	$p < 0.05$
Microbial N (g/kg) DOMR [§]	18.28	14.74	13.80	3.405	NS

[¶] Purine derivatives = allantoin + 15% correction for uric acid (Chen and Gomes, 1992).

[§] DOMR = Digestible organic matter (DOM) apparently fermented in the rumen = DOM × 0.65 (ARC, 1980).

^{a,b} Values with different superscripts in the same row differ significantly. Ns = Non significant.

Table 5. Nitrogen utilization by native growing bulls fed urea-molasses-straw (UMS), urea-rice gruel straw (UGS) or urea-straw (US)

Parameters	UMS	UGS	US	SED (*Residual df* = 9)	Significance
Total N intake (g/d)	83.00^{a}	75.00^{b}	65.00^{b}	4.92	$p < 0.05$
Faecal N excretion (g/d)	37.00^{a}	23.50^{b}	28.50^{ab}	6.081	$p < 0.05$
Urinary N excretion (g/d)	27.85^{a}	33.70^{ab}	36.38^{a}	3.378	$p < 0.05$
N balance (g/d)	18.00^{a}	17.55^{a}	6.13^{b}	6.147	$p < 0.05$
N intake (mg/kg $W^{0.75}$/d)	1,185	1,109	1,054	59.97	NS
N balance (mg/kg $W^{0.75}$/d)	260	227	94	104.2	NS

kg/d) followed by UGS (1.461 kg/d) and US (1.293 kg/d). The estimated metabolizable energy (ME) intake of UMS, UGS and US were 396, 348 and 301 kJ/kg $W^{0.75}$/d respectively. Dietary energy concentration was very similar (approximately 5.5 MJ/kg DM intake) in all the three groups.

Table 6. Estimated energy intake by native growing bulls fed urea-molasses-straw (UMS), urea-rice gruel straw (UGS) or urea-straw (US)

Parameters	UMS	UGS	US	SED (*Residual df* = 9)	Significance
Digestible organic matter (kg/d)	1.776	1.461	1.293	0.245	NS
Metabolizable energy (ME) intake (MJ/d)¶	27.64	22.73	20.12	3.81	NS
ME intake (kJ/kg $W^{0.75}$/d)	396	348	301	77.75	NS
Energy concentration (MJ/kg DM)	5.41	5.71	5.29	–	–

¶ The metabolizable energy intake estimated from the digestible OM (DOM) intake; DOM (kg) × 15.56; (ARC, 1980).

Growth rate

Live weight changes during the experimental period are shown in table 7. During the 60 days of experimental period, animals fed UMS and UGS gained liveweight while, those fed US lost weight. Daily live weight changes in UMS, UGS and US were 292, 125 and –19 g respectively.

Table 7. Live weight change of growing bulls fed urea-molasses-straw (UMS), urea-rice gruel straw (USG) or urea-straw (US) during the experimental periods (60 days)

Parameters	UMS	UGS	US	SED (*Residual df* = 9)	Significance
Initial weight (kg)	272.0	271.0	276.0	123.3	NS
Final weight (kg)	289.5	278.3	274.9	26.0	NS
Growth rate (g/d)	292	125	–19	87.63	NS

DISCUSSION

The main objective of the trial was to test the use of rice gruel compared to that of the cane molasses as a source of readily fermentable energy for a urea supplemented straw. Impregnation of urea-enriched straw with molasses or rice gruel expected to increase the productivity of animal over that of the control.

Effect on intake

Primary limitation to DM intake from straw is its inadequate readily fermentable OM and N contents (Leng, 1990). In the present trial, theoretical requirement for the readily fermentable N was met by supplying 3% urea (Huque and Chowdhury, 1995), while the source and amount of readily fermentable energy varied between the treatments. Two points are apparent from the result of DM and OM intake: 1) supplementation of readily fermentable energy (from molasses or rice gruel) increased the straw intake over that of the unsupplemented group, and 2) responses of molasses was better than the rice gruel. As per as the 1st point is considered, on a high fibrous diet, molasses or starch increases the microbial fermentation of fibrous material and fractional outflow rate of solid material (Hemsley and Moir, 1963). As per as the 2nd point is concerned, molasses provided more fermentable sugar (325 *vs.* 43 g/kg of the liquid) and minerals (22.66 *vs.* 0.12 g per 100 g of solid) than the rice gruel, which are essential for efficient microbial growth on a straw diet.

Net effect of these factors would be an increase in MN yield (see table 4), which will increase the straw intake by increasing the quantity of amino acid absorbed from the intestine (Hennessy et al. 1983).

Effect on digestibility

Despite higher intake of straw by the UMS and UGS fed animals, digestibilities of DM and OM in these animals were very similar to that of the control (US). This means that these animals had higher available nutrient supply than that of the control. Lower N digestibility in the UMS than the US or UGS fed animals may not necessarily indicate that they had lower available amino acid N (AAN) supply at the tissue level. Because faecal N comprises of undigested dietary N and metabolic faecal N (MFN). Microscopic observations and microbial marker study revealed that MFN was virtually all undigested microbial N (Ørskov, 1982). The later is proportional to the microbial N yield in the rumen. Therefore, depending on microbial N yield, apparent N digestibility may vary without actual change in the AAN availability to the host animal (Chowdhury et al., 1995).

This means that despite the lowest apparent N digestibility, the UMS animals might had higher available AAN supply as indicated by the higher MN yield in that group (table 4). Digestibility of ADF was significantly higher in the US than the UGS or UMS. One possible reason could be that, higher DM intake by the UMS and UGS fed animals resulted in increased fractional outflow rate of solid digesta, with the consequent reduction in the fibre digestibility (Hemsley and Moir, 1963).

Microbial N yield

All the three groups of animals were supplied with the same level (3%) of readily fermentable N (urea) but with different estimated amount of readily fermentable energy. Straw when enriched only with 3% urea, the MN yield was approximately 11 g/d, which is similar to our previous observation of 6-11 g MN/d on a similar diet (Chowdhury et al., 1995). However, when straw was enriched with both urea and rice gruel, the MN yield further increased but the highest MN yield was observed when straw was enriched with both urea and molasses.

Two points are apparent from the result of MN yield: 1) supplementation of readily fermentable energy (molasses or rice gruel) increased the MN yield over that of the unsupplemented group, and 2) responses of molasses was better than the rice gruel. As per as the 1st point is considered, on a high fibrous straw diet, molasses or starch a) provide necessary energy and minerals essential for microbial growth, b) could partly spare branched-chain volatile fatty acids requirement of many cellulolytic organisms (*Ruminococcus flavefacienns, R. albus, Butyrivibrio fibrisolvens*; Gylswyk, 1995). and c) increase the fractional outflow rate of rumen digesta as indicated from the increased DM intake (Fiachney, 1986). Net effect of these higher substrate availability (Faichney and Black, 1979; Leng, 1984) and outflow rate (Rode et al., 1985; Chen et al., 1992) would be higher MN yield in the UMS and UGS than the US.

As per as the 2nd point is concerned, molasses provided more fermentable sugar (325 vs. 43 g/kg of the liquid) and minerals (22.66 vs. 0.12 g per 100 g of solid) than the rice gruel, which are essential for efficient cellulolytic activity on a straw diet. Therefore, the net effect will be higher MN yield in the UMS than the UGS fed animals. Thus, in situation where molasses is costly or not available, enriching straw with rice gruel (which is already availabel at the farmers level) and urea can support relatively higher amount of MN yield than feeding straw alone.

As expected, microbial N yield was closely related to the ME intake. Regression between the estimated ME intake (X, MJ/d), and MN yield (Y, g/d) was as follows (also see figure 1):

$Y = 1.29 \pm 0.134(X) - 14.79$ ($r = 0.99$; $n = 3$; $p < 0.06$) .... Eqn. 1

For each MJ increase in ME intake, the MN yield was 1.29 ± 0.134 g, which is slightly lower than the ARC (1984) adopted value of 1.34 g/MJ ME.

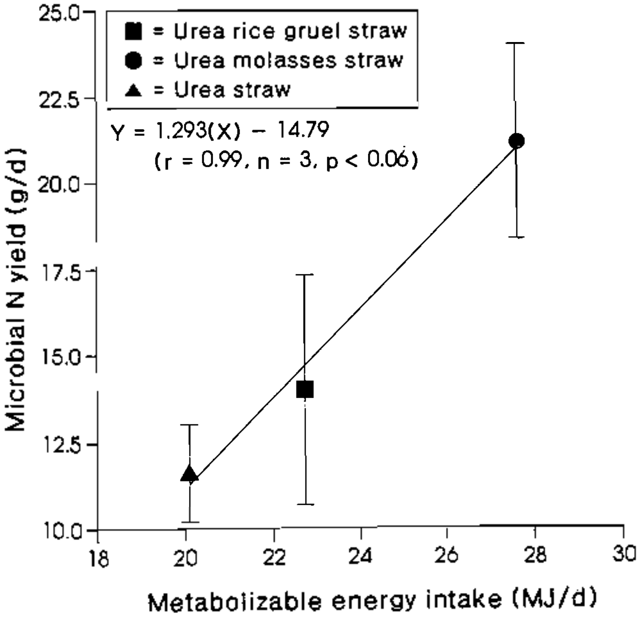

Figure 1. Microbial N yield in response to different levels of estimated metabolizable energy intake from straw enriched either with urea (3%), or urea (3%) + molasses (15%) or urea (3%) + rice gruel (30%). Each point represents the mean of four animals with vertical bar as the standard error.

Effect on growth rate

Daily live weight gain (Y, g/d) was the highest in UMS followed by UGS and US, and was linearly related to the ME intake (X_1, kJ/kg $W^{0.75}$/d) and MN yield (X_2, g/d) (also see figure 2a and 2b):

$Y = 3.27\ (\pm 0.1198)\ X_1 - 1{,}007$ .... Eqn. 2

$Y = 30.64\ (\pm 7.353)\ X_2 - 344$ .... Eqn. 3

Supplementation of rice gruel yielded medium levels of both energy and protein yielding nutrients with the consequent medium level of growth rate compared to that of the UMS and US. This kinds of relationship was obvious as the live weight gain depends mainly on the supply of amino acids and energy yielding substrates delivered to the tissues, up to the genetic limit for protein synthesis (Poppi and McLennan, 1995).

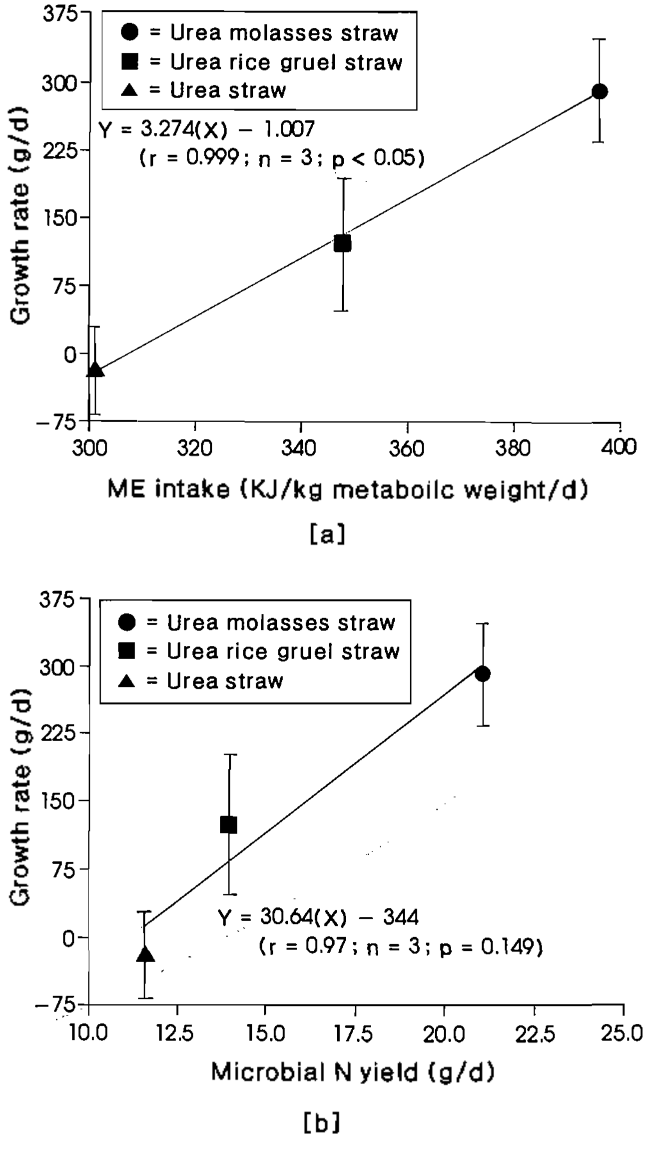

Figure 2. Live weight change of different groups of animals in response to (a) different levels of estimated metabolizable energy intake or (b) different amounts of microbial N yield. Each point represents the mean of four animals with vertical bar as the standard error.

From equation 2, it can be calculated that animals attained zero live weight gain (i.e., at maintenance) at the estimated ME intake of 308 kJ/kg $W^{0.75}$/d, which is less than the ARC (1980) reviewed maintenance energy requirement of 400-570 kJ/kg $W^{0.75}$/d for the temperate cattle, This could partly be due to genetic make up of the animal, as Indian cattle and buffalose found have lower basal metabolic rates than temperate breeds and consequently lower maintenance requirements (Ranjhan and Singh, 1993). However, the value (308 kJ/kg $W^{0.75}$/d) is far less that observed for a 250 kg Indian cattle of 480 kJ/kg $W^{0.75}$/d (Ranjhand and Singh, 1993). It may be that prolonged undernutrition resulted lower maintenance energy requirement of experimented animals, because, long term undernutrition results in adaptive reduction of basal metabolic rate (Waterlow, 1989) such that for each 1 kJ/kg $W^{0.75}$/d changes in preceding energy balance, fasting metabolism changes by 0.2 kJ/kg $W^{0.75}$/d (Chowdhury, 1992).

The present study provides evidence that rice gruel together with urea can improve productivity of growing bulls on an absolute rice straw based diet. Howerver, as supplement, molasses was much more effective than rice gruel apparently due to higher fermentable carbohydrate and mineral content in the former. Supplementary fermentable energy source apparently removed a restriction on voluntary intake and provided extra amino acids of microbial origin for absorption from small intestine. This in turn provided substrates for protein synthesis and gluconeogenesis required for growth. However, in situation where molasses is not available or costly, rice gruel does appear to have a place as readily fermentable energy source on urea supplemented straw diet.

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