



Optimization of Urea Supplementation to Goats in Cooked Rice Feeding Regimen Followed in Tamil Nadu

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ABSTRACT

Background: Cooked rice had a low crude protein ranging between 9.2 and 12.6% but had a remarkably high nitrogen free extract (NFE above 84%) indicating a very wide gap in the available nitrogen to available soluble carbohydrate. Hence, the study was undertaken to investigate the effects of urea supplementation in cooked rice feeding regimen on nutrient utilization and production performance of goats.

Methods: The *in vitro* dry matter and protein degradability characteristics of cooked rice were determined by using rumen simulation technique (RUSITEC). An animal experiment was conducted in twenty-four non descriptive kids at 90 days of age randomly divided into four treatments (T1 - 0%, T2 - 1.5%, T3 - 2.0% and T4 - 2.5% of urea in the diet as such basis) for 180 days. The average daily gain, daily feed intake and feed conversion ratio were recorded during the trial. The digestibility trial was conducted at the end of the trial for 15 days.

Result: Rumen fermentation pattern of cooked rice revealed lower ruminal pH (5.5), effective degradability of DM and N of cooked rice were 52.5% and 33.2% respectively with 0.44% of rumen digestible nitrogen and 1.42% of potential microbial nitrogen production. The scope of urea supplementation was 1.85%. The average daily gain was 53.23, 71.66, 96.75 and 76.91g/day and feed conversion ratio were 9.70, 7.74, 6.61 and 8.52 in groups 0, 1.5, 2.0 and 2.5% respectively was significantly ($P < 0.01$) improved in 2.0% urea supplementation over other treatments. Hence, it is advocated the supplementation of urea at 2.0% level as such basis along with cooked rice for enhanced growth performance of goats.

Key words: Cooked rice, Goat, Rusitec, Urea.

INTRODUCTION

Goat, the poor man's cow, facilitates the rural farmer's employment and income in India. Majority of small and marginal farmers depend on goat farming for their livelihood. In India, goats feeding based on, natural grasses, crop residues, supplemented with a little or no concentrates is mainly practiced, resulting in their sub optimal productivity.

Goat farmers of southern India, especially Tamil Nadu, have been feeding their goat with cheap and abundantly available feed resources, which includes cooked rice. The cooked rice is fed along with rice bran to goats by medium farmers. The nutrient requirements of the animals do not meet according to their production and reproduction. Earlier observation by the author (Murugeswari *et al.*, 2020) revealed that cooked rice had a low crude protein ranging between (9.2 to 12.6%) but had a remarkably high nitrogen free extract (NFE) (above 84%) indicating a very wide gap in the available nitrogen to available soluble carbohydrate. Hence, it is advocated to provide adequate degradable protein to ferment available carbohydrate in the cooked rice to increase microbial protein production.

Urea is the non- protein nitrogen, highly soluble in the rumen, which produces ammonia and the synchrony of ammonia production with energy sources for the synthesis of microbial protein. Zhang *et al.* (2016) also reported that urea can be supplemented as an inexpensive rumen

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degradable protein source to improve microbial protein production and animal performance. Hence, the study was undertaken to investigate the effects of urea supplementation in cooked rice feeding regimen on nutrient utilization and production performance of goats.

MATERIALS AND METHODS

Location

The study was conducted at private goat farm, Nelvoy village, Madurantakam, Chengalpattu, Tamil Nadu which is located at 12.6170°N latitude and 79.8232°E longitude at an altitude of 28 m above mean sea level during the years 2015 to 2016.

RUSITEC experiment

Rice samples were collected from the field of six locations and cooked with water in the ratio of 1:10, in boiling water bath to a gel like consistency which was similar to cooked rice fed by farmers (Oko *et al.*, 2012). It was dried in hot air oven at 105°C till complete removal of moisture and ground to pass through 1 mm sieve in Willey mill for chemical composition (AOAC, 2012) and degradability studies. The *in vitro* dry matter and protein degradability characteristics of cooked rice were determined by using rumen simulation technique (RUSITEC) described by Czerkawski and Breckenridge (1977). The rumen liquor for RUSITEC was collected from adult Jersey crossbred cattle maintained on grazing (Murugeswari *et al.*, 2022). The liquor was collected from three animals, pooled and this composite sample was strained in 4 layers muslin cloth to represent strained rumen liquor. The solid rumen content was collected using tongs from the same animals and was used as solid inoculum to imitate the fermentation in the reaction vessel. The experiment trial consisted of a seven day adaptation period followed by collection period. Five grams of dried cooked rice material was placed in 100µ nylon bag in each reaction vessel, and it was incubated at 3, 6, 9, 12 and 24 hours. The dry matter and nitrogen degradability were studied for all incubation hours with exponential equation (Mc Donald, 1981). The rumen fermentation characteristics such as ruminal pH, ammonia nitrogen (Souza *et al.*, 2013), volatile fatty acids (Chase, 1990), microbial protein were analysed (Nocek *et al.*, 1979). The Neway (2010) software was used to study the effective dry matter and nitrogen degradability.

Experimental animals

A total of twenty-four non descriptive kids weighing 5.2±0.8 kg at 90±15 days of age were randomly divided into four equal treatments. The animals were housed with the shed, dewormed, vaccinated, and fed with clean potable drinking water *ad libitum*. The animals were treated for minor ailments when it arises with standard treatment therapy. All animals of the selected farmers and farm were ear tagged at the beginning of the study.

Experimental design

Four treatments were designated to T1, T2, T3 and T4. Treatments are T1 - 0%, T2 - 1.5%, T3 - 2.0% and T4 - 2.5% of urea in the diet. The urea supplementation level was fixed based on the earlier study conducted by the author on potential microbial nitrogen production and scope of urea supplementation of cooked rice. Animals were offered hybrid napier grass (CoCN4) *ad libitum*. Every day cooked rice was fed along with urea after mixing it to each animal. The feed and fodders were offered individually. The adaptation period of 15 days was allowed before the actual start of the experiment. The experimental animals were fed as per their body weight following ICAR (2013) requirements. The animals were allowed *ad libitum* access

to clean potable water. The experiment was conducted for 180 days. The feed intake and feed left over was recorded every day and the body weight was recorded every fortnight in the morning before feeding with the use of platform type electronic weighing balance. Average daily gain, daily feed intake and feed conversion ratio were recorded during the trial. The digestibility trial was conducted at the end for 15 days. The feed offered and dung voided were recorded. Rectal fecal samples were collected on days 1, 2, and 3 of week 24 from each goat before feeding (Zhu *et al.*, 2020). Samples of daily feed offered, and feces were stored frozen until the end of the 12-week period and then pooled for the whole experimental period and dried in hot air oven at 80°C to constant weight and stored and ground with a 1 mm mesh Wiley mill for chemical analysis as per AOAC, (2012).

Statistical analysis

The data were subjected to one-way analysis of variance (ANOVA) using (Snedecor and Cochran, 1994). Means showing significant differences in the ANOVA table were compared using the Duncan multiple range test (Steel and Torrie, 1980). A p-value of 0.05 was considered statistically significant and 0.01 was considered highly significant.

RESULTS AND DISCUSSION

The chemical composition of hybrid napier grass (CoCN4) and cooked rice is shown in Table 1. The DM, CP and EE content of cooked rice was highest than reported values (Adepoju *et al.*, 2016; Murugeswari *et al.*, 2018). NFE of above 84% was documented in cooked rice samples. Mir *et al.* (2017) also stated that starch is the major constituent of rice and protein is the second highest component after starch in rice kernel. The TA content of cooked rice showed a poor source of minerals. The DM, CP and CF of hybrid napier (CoCN4) grass fodder was also similar with published value (Sultana *et al.*, 2012; Mahfuz *et al.*, 2018).

The rumen fermentation characteristics of cooked rice at 24 hours of incubation was conducted by author earlier (Murugeswari *et al.*, 2022) and the results are presented in Table 2. The results viz. lower pH (5.5), higher propionic acid and total volatile fatty acid (TVFA), lower ammonia nitrogen and lower microbial protein synthesis clearly lean the favour against cooked rice. The higher TVFA (98.32 mM) seems to be a result of lower the ruminal pH. Fermentation

Table 1: Chemical composition (Mean±SE) of Hybrid napier grass (CoCN₄) and cooked rice on dry matter basis.

Parameters	Hybrid napier grass (CoCN ₄)	Cooked rice
Dry matter (%)	24.53±1.42	34.21±1.79
Crude protein (%)	9.72±0.74	10.64±0.11
Crude fiber (%)	31.45±1.83	0.73±0.02
Ether extract (%)	1.32±0.07	1.36±0.08
Total ash (%)	14.89±1.36	0.79±0.04
Nitrogen free extract (%)	42.49±2.86	86.47±4.98

*Mean of six samples.

of carbohydrates releases organic acids that readily dissociate to decrease pH (Russell and Rychlik, 2001). Production of VFA mostly depends on the fermentation of the carbohydrate present in the feed (Herdian *et al.*, 2011). The acetate to propionate ratio (1.35) is lower which improves ruminal fermentation efficiency as energy is available for rumen microbial activities. Non glucogenic ratio mirrors the utilization of volatile fatty acid. The energetic efficiency was 128.67 which the metabolically useful energy recovered in fermentation end products can be increased by enhancing the production of propionate and to a lesser extent butyrate at the expense of acetate production (Baran and Zitnan, 2002).

The nutrients degradability in cooked rice at 3, 6, 9, 12, 18 and 24 hours of incubation is presented in Table 3. At the end of 24 hours incubation the dry matter, organic matter and nitrogen degradability were increased. Earlier the author recorded that 68.5% DM degradability, 65.7% OM degradability and 44.3% N degradability. The effective degradability of DM and N in cooked rice was reported that 52.5% and 33.2% (Murugeswari *et al.*, 2022). The degradability characteristics of nutrients in cooked rice is presented in Table 3. The nitrogen degradation rate (0.10) was higher than dry matter degradation rate (0.07). Davidson *et al.* (2003) reported higher rumen fermentation rate in cows fed high rumen degradable protein than those fed low rumen degradable protein in their diet. As compared to this study, Gonzalez *et al.* (2003) reported higher soluble dry matter, higher insoluble but degradable dry matter and higher effective degradability in corn. A very high percentage for quickly soluble and degradable nitrogen fraction "a" (52.90%) in barley and nitrogen degradation of 0.060 to 0.131% per hour, was reported by Kopceková *et al.* (2008). The partitioning of total nitrogen in cooked rice is presented in Table 4. The RDN was 0.58% from total nitrogen of 1.74%. The digestibility of RDN is 0.44%. The potential microbial nitrogen production was derived 1.42% due to the low protein and high soluble carbohydrates of cooked rice are attributed to minimizing rumen microbial protein synthesis due to the timely non availability of nitrogen and carbohydrate from cooked rice that are averted rapid microbial growth. When only cooked rice is fermented *in*

vitro there is a mismatch between available energy and protein, which indicates that a source of nitrogen needs to be supplemented for energy protein synchrony to augment microbial biomass production (NRC, 2021).

The difference between RDN and potential microbial nitrogen production reveals the scope for either NPN supplementation or digestible organic matter supplementation to fully exploit the nutritive value of substrate. The assessment for the need of supplemental nutrients for cooked rice is presented in Table 5. The availability of rumen degradable nitrogen (RDN) when compared to potential microbial nitrogen revealed that there is scope for further improvement in the microbial production through NPN supplementation (Murugeswari *et al.*, 2007). An adequate dietary carbohydrate of rapidly digestible non-structural type with sufficient nitrogen in diet may promote microorganism proliferation and usage of ammonia nitrogen and increase microbial crude protein (MCP) synthesis (Sarkar *et al.*, 2022).

The effect of urea supplementation with cooked rice on growth performance of goats is presented in Table 6. The live weight gain of experimental goats increased significantly ($p < 0.01$) in the 2.0% urea supplemented group. Urea supplementation improves the degradability of nutrients in the cooked rice and increases the microbial production which supports the availability of protein to the

Table 2: Rumen fermentation characteristics (Mean^{**} ±SE) of cooked rice* at 24 hours of incubation.

Parameters	Rumen fermentation characteristics
pH	5.5±0.04 ^a
NH ₃ -N (mM)	2.14±0.11
Total VFA (mM)	98.32±3.7
Acetate (mM)	53.59±2.9
Propionate (mM)	42.18±2.2
Butyrate (mM)	2.78±0.06
Acetate to propionate	1.35±0.02
Non glucogenic ratio	1.45±0.01
Energetic efficiency	86.47±6.98

*On dry matter basis; **Mean of six samples.

Table 3: Nutrient degradability at 3, 6, 9, 12, 18 and 24 hours of incubation and Degradability characteristics of nutrients in cooked rice* (Mean^{**} ±SE).

Incubation hours	DM degradability (%)	OM degradability (%)	N degradability (%)	Degradability Characteristics	DM	N
3	32.2±1.8	30.4±1.4	16.2±1.2	Nutrient degradation rate/ hour	0.07±0.01	0.10±0.01
6	39.6±2.1	37.3±1.8	24.6±1.1	Soluble degradable fractions (%)	19.3±0.8	5.4±0.2
9	45.8±2.7	43.6±2.5	31.5±1.8	Insoluble degradable fractions (%)	59.3±2.9	44.3±2.2
12	51.7±2.5	48.6±2.4	34.7±1.9	Undegradable fractions (%)	29.4±1.6	51.3±2.5
18	59.5±3.3	56.4±3.7	41.9±2.2	Effective degradability of nutrients (%)	52.5±2.8	33.2±1.9
24	68.5±3.7	65.7±3.2	44.3±2.3			

*On dry matter basis; **Mean of six samples.

animal and increases the live weight gain (Chellapandian *et al.*, 2022). T1 animals showed the lowest live weight gain due to the cooked rice feeding alone developing the ruminal acidosis which increased the fibre intake (Bramley *et al.*, 2008). The effect of urea supplementation on dry matter intake (DMI) ranged from 517 to 642g/day, highest level was observed in T3 and T4 indicating that the improves the starch digestion which increased the DMI. Barbosa *et al.* (2012) found significantly ($P<0.01$) decreased DMI with feeding 20 g/kg of urea in partial substitution of soyabean meal. Polviset and Danopas (2022) observed increased dry matter intake in urea treated rice straw (0.71 kg/day). The feed conversion ratio (FCR) was significantly ($P<0.01$) decreased in T3 with 2.0% of urea supplementation. Since the growth performance was improved by increasing live weight gain 17.34kg and decreased the DMI of 2.84% which automatically reduces the FCR (Mazinani *et al.*, 2022).

The effect of urea supplementation with cooked rice on nutrient digestibility of goats is presented in table 7. The apparent digestibility of nutrients increased in T3. The crude protein digestibility of T3 (75.72%) was increased due to the availability of rumen degradable protein with highly fermentable carbohydrates (Zinn *et al.*, 2003). The crude protein digestibility was decreased in T1 due to the crude protein content of cooked rice is low and non-fiber carbohydrate content is high. Concurring with the results of this study, Johnson and Johnson (1995) also reported that adding urea as a source of rumen degradable protein (RDP) increases microbial crude protein production and contributes to metabolizable protein supply to the animal. The organic matter

digestibility was highly significant in T3 at 2.0% urea supplementation. Zinn *et al.*, (2003), also reported that in a steam flaked barley-based finishing diet, urea supplementation increased slightly (2%; quadratic, $p<0.01$) total tract organic matter digestion. NDF and ADF digestibility was also increased on T3. The synchronization of energy and nitrogen sources in rumen can improve microbial protein synthesis (Joo *et al.*, 2005).

Table 4: Partitioning of total nitrogen in cooked rice* (Mean^{**}±SE).

Parameters	Cooked rice*
Total nitrogen (%)	1.74±0.06
ERDN (%)	0.58±0.01
Digestible RDN (%)	0.44±0.02
Digestible RDN as per cent of total nitrogen (%)	25.29±1.05
Organic matter apparently digested in the rumen (%)	48.35±2.02
Potential microbial nitrogen production (%)	1.42±0.04
Potential microbial protein production (%)	8.87±0.55

*On dry matter basis; **Mean of six samples.

Table 5: Scope for supplementation to increase the utilization of nutrients of cooked rice.

Parameters	Cooked rice
RDN (%)	0.58
Potential microbial nitrogen (%)	1.42
Per cent difference in nitrogen	+0.84
Scope for urea supplementation (%)	1.85

Table 6: Effect of urea supplementation with cooked rice* on growth performance of goats (Mean^{**}±SE).

Parameters	T1	T2	T3	T4
Initial live weight (kg)	5.82±0.36	4.83±0.92	5.19±0.78	6.02±0.51
Final live weight (kg)	14.12±1.44 ^a	16.17±1.86 ^b	22.59±1.13 ^d	19.52±1.35 ^c
Total live weight gain (kg)	9.59±0.98 ^a	12.81±1.02 ^b	17.34±1.19 ^c	13.76±1.05 ^b
Average live weight gain (g/day)	53.23±2.71 ^a	71.66±3.82 ^b	96.75±4.33 ^c	76.91±3.48 ^b
Dry matter intake from cooked rice (kg/day)	0.074±0.01 ^a	0.092±0.01 ^b	0.153±0.01 ^d	0.114±0.01 ^c
Dry matter intake from fodder (kg/day)	0.456±0.03 ^b	0.471±0.02 ^c	0.341±0.03 ^a	0.532±0.01 ^d
Total dry matter intake (kg/day)	0.517±0.02 ^a	0.558±0.01 ^b	0.642±0.01 ^c	0.642±0.02 ^c
Dry matter intake (% of Live weight)	3.66±0.01 ^d	3.45±0.02 ^c	2.84±0.01 ^a	3.28±0.01 ^b
Feed conversion ratio	9.70±0.01 ^d	7.74±0.03 ^b	6.61±0.01 ^a	8.52±0.02 ^c

*On dry matter basis; **Mean of six samples. Means bearing different superscripts differ high significantly ($P<0.01$) among treatments.

Table 7: Effect of urea supplementation with cooked rice* on nutrient digestibility of goats (Mean^{**} ± SE).

Nutrient digestibility	T1 (%)	T2 (%)	T3 (%)	T4 (%)
Dry matter	62.83±1.57 ^a	64.12±1.18 ^b	69.19±0.78 ^d	66.48±0.93 ^c
Crude protein	54.73±0.44 ^a	67.49±0.86 ^b	75.72±0.17 ^d	71.07±0.35 ^c
Organic matter	67.21±1.01 ^a	72.53±0.75 ^b	80.45±0.25 ^d	76.48±0.92 ^c
Neutral detergent fibre	58.47±1.33 ^a	61.18±1.82 ^b	66.24±1.04 ^d	63.05±1.57 ^c
Acid detergent fibre	45.26±0.87 ^a	48.29±1.01 ^b	52.47±1.06 ^d	50.07±0.98 ^c
Total digestible nutrients	53.11±0.69 ^a	58.04±0.97 ^b	68.12±1.02 ^d	60.11±1.07 ^c

*On dry matter basis; **Mean of six samples. Means bearing different superscripts differ high significantly ($P<0.01$) among treatments.

The microbial multiplication in the rumen increased the fibre digestibility. Barbosa *et al.* (2012) also reported that the urea supplementation (20 g/kg DM) increased the NDF digestibility. ADF was increased with 0.8% urea supplementation by Zinn *et al.* (2003).

CONCLUSION

Cooked rice feeding requires the supplementation of readily degradable protein to increase microbial production. The supplementation of 2.0% level of urea along with cooked rice as such basis increased the apparent digestibility, feed intake, live weight gain and reduced the feed conversion ratio. Hence, it is advocated that the optimization of urea supplementation at 2.0% as such basis level along with cooked rice increases the production performance of goats where the cooked rice feeding regimen followed in Tamil Nadu.

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Conflict of interest

The authors declare that they have no conflict of interest.

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