



Growth and Economics of Sheep Fed With Coated Non Protein Nitrogen.

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Growth Performance and Economics of Sheep Production Fed With Coated Slow Release Non-Protein Nitrogen Products

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ABSTRACT

A study was conducted on 30 ram lambs (3-4 month old; 14.7±0.49 kg body weight) randomly allotted to 5 dietary treatments with 6 animals in each group in a completely randomized design to evaluate the effect of supplementation of SRNPN products on growth performance, nutrient utilisation and blood biochemical constituents. The 5 maize stover based complete diets (2190 kcal ME/kg and 14.6% CP) were prepared *viz.* control diet with SBM as major protein source (45% CP) and without any non protein nitrogen supplement, positive control diet, having urea (46% N) around 1% of dietary DM and in other 3 diets, urea was totally replaced with fat coated urea (FCU), Calcium salts of fatty acid coated urea (CFCU) and Hydroxypropyl methylcellulose coated urea (HMCCU). Supplementation of slow release non protein nitrogen (SRNPN) products did not affect the fortnightly body weight, average daily gain and dry matter intake throughout the study. The blood collected at start and 120th day indicated no effect on blood biochemical constituents. While the blood urea nitrogen concentration was higher ($P<0.01$) in urea diet fed lambs while in SRNPN fed lambs, it was comparable to control. The cost of feeding per kg gain was higher in urea diet fed lambs by 23.52% compared to control. While in FCU, CFCU and HMCCU fed lambs, it was lowered by 16.18, 20.56 and 15.98%, respectively compared to urea fed lambs. In comparison to control group, cost of feeding per kg gain increased by 3.59 and 3.85% for FCU and HMCCU and decreased by 1.91% in CFCU group respectively.

KEYWORDS: Average daily gain, Blood biochemical constituents, Cost economics, Lambs, Slow release urea products.

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INTRODUCTION

Protein is one of the important nutrient in ruminant nutrition, not only provides amino acids to the animal, but also as a source of nitrogen (N) for microbial protein synthesis. The final protein supply to the small intestine is formed by dietary protein and microbial protein. Microbial protein synthesized in the rumen can supply more than 50% of the amino acids absorbed by ruminants, being considered a protein of high biological value (AFRC, 1993). Therefore, optimization of microbial synthesis is one of the main objectives of researchers in ruminant nutrition. The price of protein sources for animal feeding are in increasing trend, non-

protein nitrogen is an alternative to partially replace true protein sources (*i.e.* soybean meal) in ruminant diets to decrease feeding cost and maintaining animal performance. Urea is the most commonly used non-protein nitrogen sources to meet N requirements of rumen microorganisms (Ayasan 2009). However, urea can be rapidly hydrolyzed to ammonia in rumen and exceeds the capacity of its conversion into microbial N, because the rate of carbohydrate fermentation is slower than the rate of urea hydrolysis (Galo et al., 2003). The excess ammonia can be absorbed by ruminal epithelium, metabolized into urea by the liver, and excreted in urine increasing the N losses.

There are many technologies available to slow down the rate of degradation of urea to ammonia among them coating of urea with fat and polymers have given promising results in ruminants with respect to less ammonia peaks in rumen fluid, suggesting a greater N utilization by rumen micro-organisms (Taylor-Edwards et al., 2009). Positive effects of feeding slow-release urea (SRU) on average daily gain and cost economics have been reported in literature (Angulo et al., 2016; Ji et al., 2016; Zulfiqar Ahmed et al., 2017). However, other studies have reported no effects of replacing feed grade urea by SRU on blood biochemical parameters, average daily gain and cost of production in sheep (Tufarelli et al., 2009; Cherdthong et al., 2010; Gardinal et al., 2017).

Considering the aforementioned facts, our hypothesis was that lambs fed with SRNPN would improve growth rate, nutrient digestibility, nitrogen balance and cost economics. Therefore, a study was designed to investigate the effect of partially replacing soybean meal (SBM) with SRNPN products on growth rate, nutrient digestibility,

nitrogen balance and cost economics.

MATERIALS AND METHODS

Source of slow release urea products and other feed ingredients

Slow release urea products (SRUP) sources having 40% nitrogen under the investigation were fat coated urea (FCU) procured from M/s. Alltech Biotechnology Private Limited, Bangalore, India; Calcium salts of fatty acid coated urea (CFCU) and Hydroxypropyl methylcellulose coated urea (HMCCU) procured from Kemin Agri foods, Chennai, India. All the products contained 40% nitrogen. The maize stover was procured from college farm and concentrate feed ingredients (maize, soybean meal, urea, salt and mineral mixture) were procured from the local market.

Experimental diets

The total mixed ration for control group was formulated with Maize stover, maize grain and SBM as major protein source (45% CP) and without any supplement of non protein nitrogen sources. (Table 1).

Table 1. Ingredient composition (%) of complete rations containing various slow release non protein nitrogen products fed to growing lambs

Ingredient	Control	Urea ¹	FCU ²	CFCU ³	HMCCU ⁴
Maize stover	48.4	50.7	50.6	50.6	50.6
Maize grain	32.3	36.1	36.0	36.0	36.0
Soybean meal	18.4	11.4	11.4	11.4	11.4
Mineral and vitamin mixture*	0.3	0.3	0.3	0.3	0.3
Salt	0.6	0.6	0.6	0.6	0.6
Non protein nitrogen source	0.0	0.9 ¹	1.1 ²	1.1 ³	1.1 ⁴
Total	100.00	100.00	100.00	100.00	100.00
Crude protein (%)	14.6	14.6	14.6	14.6	14.6
ME (Mcal/kg)	2.19	2.18	2.18	2.18	2.18

*Mineral mixture provided per kg diet: Calcium 0.72g, Phosphorus 0.36g, Magnesium 0.18g, Iron 0.018g, Zinc 6.6mg, Copper 12mg, Iodine 0.6mg, Cobalt 0.3mg, Vitamin B₁ 3.9mg, Vitamin B₆ 0.39mg, Vitamin B₁₂ 9mg, Vitamin A 3300IU, Vitamin D₃ 600IU and Vitamin E 0.6 IU.

Sodium sulphate was added over and above to urea, FCU, CFCU and HMCCU ration at the rate of 0.4%

¹ Urea contained 46% N and all other coated non protein nitrogen products contain 40% N.

² Fat coated urea.

³ Calcium salts of fatty acids coated urea.

⁴ Hydroxypropyl methylcellulose coated urea.

The total mixture ration in positive control group was prepared by partially replacing SBM nitrogen in the basal complete feed with urea @ 1% of DMI having 46% nitrogen. In the other three experimental total mixed rations, the urea in the positive control was totally replaced FCU, CFCU and HMCCU. All the total mixture rations were iso-nitrogenous and iso-caloric and contained 14.6% CP and 2190 kcal ME/kg, respectively.

Experimental animals and management

Thirty Tumkur breed male lambs (3-4 months of age) with average body weight of 14.73 ± 0.49 kg were purchased from a shepherd of Tumkur district of Karnataka, India. After initial quarantine and adaptation period for 15 days, they were randomly divided into 5 groups consisting of 6 animals each in a completely randomized design. Lambs were fed individually with respective rations to meet the nutrient requirement for maintenance and growth (100g/day) as per ICAR (2013) twice in a day at 9.00AM and 3.00PM in equal proportions. The residues if any were weighed on the next day at 9.00AM to arrive at the daily feed intake. Fresh drinking water was made available at all the times. All lambs were adapted to urea containing complete feed gradually for about 7 days prior to feeding experimental rations.

Feed analysis

Feed samples of various experimental diets were analyzed for proximate constituents as per AOAC (2016).

Blood collection and biochemical estimation

Blood was collected aseptically from jugular vein of rams in to clean sterilized glass tubes at start of the experiment and on 120th of day growth trial. The collected serum samples were centrifuged at 3000

rpm for 5 min, transferred to 5 ml eppendorf tubes and stored at -20°C for estimation of biochemical constituents.

Glucose in serum was estimated based on enzymatic method (Trinder, 1969), total protein by biuret method as described by Reinhold (1953) and Bromocresol green (BCG) (Doumas et al., 1971) method was used to estimate albumin content of serum. Globulin concentration in the serum was calculated by difference of the albumin from total protein. The blood urea nitrogen (BUN) was estimated as per the procedure of Tietz et al. (1995), SGPT was estimated based on Modified Reitman and Frankel (1957) method and SGOT content of serum by modified IFCC (1986) method. To estimate lipid peroxidation procedure described by Cannan (1966) was followed and Glutathione peroxidase activity was determined by the method of Paglia and Valentine (1967).

Statistical analysis

The data was subjected to one-way analysis of variance under a completely randomized design. Blood biochemical parameters collected at different intervals of time were analysed in two way analysis of variance for studying the interaction effects as per the procedure of Snedecor and Cochran (1980) by using SPSS 20. The difference between means was tested by significance using Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Chemical Composition of Experimental Diets

The chemical composition of dietary treatments were similar (Table 2) as only the SBM in the control diet was replaced with either urea or coated SRNPN sources and the rations were formulated to be iso-nitrogenous and iso-caloric.

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Table 2. Chemical composition of complete diet (% dry matter basis) containing various slow release non protein nitrogen products fed to growing lambs

Constituent	Control	Urea ¹	FCU ²	CFCU ³	HMCCU ⁴
Dry matter	91.2	91.2	90.6	90.2	91.2
Organic matter	92.5	93.4	93.1	93.2	92.5
Crude protein	14.5	14.6	14.6	14.6	14.6
Rumen degradable protein (% of CP)	8.75	9.82	9.89	9.91	9.87
Rumen undegradable protein (% of CP)	5.83	4.82	4.77	4.77	4.74
Ether extract	1.32	1.88	2.02	2.09	1.77
Crude fibre	36.4	41.8	40.6	41.3	42.0
Nitrogen free extract	40.2	35.03	35.77	35.14	34.06
Total ash	7.44	6.57	6.87	6.75	7.47
Neutral detergent fibre	60.0	61.3	59.8	61.2	60.2
Acid detergent fibre	33.4	34.2	33.5	34.4	34.4
Hemicellulose	26.5	27.1	26.3	26.8	25.7
Cellulose	27.4	28.1	27.6	28.3	28.7
Lignin	3.88	4.02	3.81	4.12	3.82

Each value is the average of duplicate analysis.

¹ Urea contained 46% N and all other coated non protein nitrogen products contain 40% N.

² Fat coated urea.

³ Calcium salts of fatty acids coated urea.

⁴ Hydroxypropyl methylcellulose coated urea.

The level of inclusion of SRNPN sources were slightly higher (1.1%) than conventional urea (0.9%) since coated urea had slightly lower protein (250%) as compared to the urea (287.5%). Replacement of SBM with urea or SRNPN sources did not affect the OM, CP, NDF, ADF, hemicellulose and cellulose content in diets.

Dry Matter Intake

The replacement of SBM with urea or SRNPN sources had no effect on average dry matter intake during the total period (120 days) in growing lambs (Table 3).

Table 3. Average fortnightly body weight changes (kg) and average daily gain (g) of lambs fed diets containing various slow release non protein nitrogen products

Body weight	Control	Urea ¹	FCU ²	CFCU ³	HMCCU ⁴	SEM	P value
Initial	14.7 ±0.72	14.7 ±1.46	14.7 ±1.63	14.7 ±0.75	14.7 ±1.18	0.498	1.00
1	17.1 ±0.92	16.5 ±1.53	16.8 ±1.97	16.4 ±1.11	16.7 ±1.02	0.572	0.99
2	19.3 ±1.13	17.9 ±1.48	18.3 ±2.04	17.9 ±1.20	18.5 ±1.26	0.614	0.96
3	21.7 ±1.28	20.2 ±1.43	20.8 ±2.32	20.2 ±1.42	20.7 ±1.27	0.671	0.95
4	23.9 ±1.32	22.2 ±1.56	22.7 ±2.45	22.9 ±1.54	23.1 ±1.55	0.728	0.94
5	25.78 ±1.39	24.07 ±1.74	24.37 ±2.52	25.06 ±1.60	25.08 ±1.75	0.775	0.88
6	27.4 ±1.47	25.5 ±1.89	25.9 ±2.54	26.8 ±1.63	26.7 ±1.86	0.806	0.81
7	29.0 ±1.59	26.8 ±2.01	27.4 ±2.56	28.4 ±1.69	28.2 ±1.94	0.837	0.94
8	30.5 ±1.69	28.1 ±2.13	28.9 ±2.57	29.9 ±1.75	29.7 ±2.02	0.869	0.93
Total gain (kg)	15.8 ±1.01	13.4 ±1.50	14.2 ±1.17	15.1 ±1.20	14.8 ±1.17	0.531	0.69
Average daily gain (g)	131.9 ±8.44	111.7 ±12.53	118.3 ±9.79	126.1 ±10.03	123.3 ±9.75	4.422	0.69

Each mean value is an average of 6 values.

¹ Urea contained 46% N and all other coated non protein nitrogen products contain 40% N.

² Fat coated urea.

³ Calcium salts of fatty acids coated urea.

⁴ Hydroxypropyl methylcellulose coated urea.

Comparable DM intake among control, urea and various SRNPN groups could be due to level of inclusion of urea/SRNPN in the present study, as inclusion of urea or SRNPN sources was at 1% of dietary DM which is quite lower to adversely affect the feed intake and feed efficiency (Taylor-Edwards et al., 2009). While at higher dietary inclusion levels

(>20g/kg DM) of urea (feed grade urea or slow-release urea) decreased the DMI in beef steers (Taylor-Edwards et al., 2009). Non significant difference in the feed intake in the present study also assert that, the amount of nitrogen from SRNPN sources was sufficient to improve rumen fermentation and prevent reduction in DMI

(Tedeschi et al., 2002) comparable DMI among lambs fed various SRNPN and control diet is also an indication that these SRNPN products were palatable. No effect on feed intake as a consequence of the supplementation of SRU and replacing urea at 0, 20, 40, 60 and 80% in diets (50 forage: 50 concentrate) have also been observed in finishing lambs (Moura et al., 2014) and in steers fed at 0.6% SRU (Optigen) (Pinos-Rodriguez et al., 2010) and 1.1% SRU (Optigen) (Castaneda-Serrano et al., 2013). On other hand tendency for reduction in the DMI and feed efficiency has been observed in some studies when feedlot cattle were supplemented with protected urea or with combinations of SRU plus urea (Huff et al., 2000; Taylor-Edwards et al., 2009) and this was attributed to insufficiency in the intake and utilisation of nitrogen leading to reduced microbial fermentation and decreased feed intake. The DMI increased with supplementation of controlled release urea (0%, 10%, 20, 30%) as a replacement to urea in sheep in studies of Duff et al. (2000) and Puga et al. (2001) to poor quality roughages which was due to better utilisation of crude fiber. The basis for the inconsistencies in the DMI in responses to SRU supplementation is not clear, but may be related to the taste of SRU products and/or diet composition (*i.e.*, inclusion of poor quality roughages).

Feed conversion efficiency

The feed conversion efficiency differed non significantly ($P>0.05$) among the different dietary groups and could be related to similarity in DM intake and body weight gain throughout the feeding trial (Table 3). Though the feed conversion efficiency was non significant among the dietary groups, in the urea based group it was lower by 10.87% compared to control group. Similarly, the feed efficiency in lambs fed with FCU, CFCU and HMCCU group was though statistically comparable it was marginally higher than urea fed group by 7.65, 7.31, 2.83 %, respectively and lower than control group. Kullu et al. (2010) also reported lower feed efficiency in control group of calves fed with 30 g of uncoated urea compared to zinc sulphate and zinc oxide coated urea supplemented group (30g/d). Angulo et al. (2016) also reported higher feed efficiency in polymer coated urea fed sheep (1.0%) compared to urea fed group (1.0%). Ji, et al. (2016)

reported best FCR in lambs when 2.13% of urea phosphate (UP) was added in concentrate mixture compared to 0, 1, 4 and 8%. Zulfiqar Ahmed et al. (2017) observed significantly ($P<0.05$) higher feed efficiency in Optigen supplemented group (10g/d) compared to control group with no Optigen supplementation. While, Pinos-Rodriguez et al. (2010) also reported no effect on feed efficiency in beef steers with feeding of polymer-coated urea product at 1% of DM compared to SBM based control group. However, Gardinal et al. (2017) observed lower feed efficiency in polymer coated urea supplemented steers compared to urea included steers with dietary inclusion at rate of 20g/animal.

Growth rate and average daily gain of lambs

The diets for the experimental lambs were formulated for target gain of 100 g per day (ICAR, 2013). All the lambs of various groups grew linearly from start of experiment till the end of 8th fortnight and average daily gain ranging from 111.71 to 131.92 (Table 3). The fortnightly body weight of lambs and ADG did not differ significantly ($P>0.05$) among the dietary groups throughout the experiment, but the average ADG in urea fed lambs was lower by 15.32% compared to control diet fed lamb. Kullu et al. (2010) also reported lower ($P<0.01$) ADG in urea fed calves compared to control (no urea) or 2% zinc coated urea fed at 30g per day. The ADG in the lambs fed CFCU and HMCCU was though statistically comparable, it was higher by 12.91 and 10.39% compared to urea fed lambs. The ADG in these two group of lambs was comparable to that of control group lambs is suggestive of better utilisation of the $\text{NH}_3\text{-N}$ released from the SRNPN sources along with the sustained release of fermentable energy from energy sources leading to improved microbial growth and microbial protein synthesis thereby enhancing the body weight gain (Lopez-Soto et al., 2015). Similar observation was recorded by Pinos-Rodriguez et al. (2010) with feeding of slow-release polymer-coated urea product (CU) incorporated at 1 per cent of dietary DM replacing 5.5% of SBM in beef steers. Angulo et al. (2016) also reported highest ADG in lambs fed diets containing urea (U) and SRU in combination of 0.8 U: 0.8 SRU compared with those *i.e.*, 0.80 U:1.0 SRU and 1.0 U:0.8 SRU. Similarly, Ji, et al. (2016) reported higher ADG in lambs with supplementation

of urea phosphate (UP) at 1 and 2% compared to 0, 4, 8% and control. Likewise, Zulfiqar Ahmed et al. (2017) observed higher ($P<0.05$) ADG in sheep with feeding of Optigen (10 g/animal twice a day for 60 days) compared to control group. Lopez-Soto et al. (2015) reported no effect on ADG with combination of urea and polymer coated urea (SRU) in crossbreed steers fed with diets containing various combinations of starch : ADF(S:F) along with urea and SRU at different percentages (0.80U:1.0SRU, 0.8 U: 0.8 SRU; 1.0U:0.8SRU). While, Gardinal et al. (2017) reported decrease ($P<0.01$) in final BW and ADG

in steers fed urea or SRU based diets compared to control.

Blood biochemical constituents

Supplementation of urea at 0.9% of the total ration or SRNPN sources at 1.1% of the total ration as partial replacement to SBM did not affect the blood concentration of glucose (mg/dl), total protein (g/dl), albumin (g/dl), globulin (g/dl), serum glutamic oxaloacetic transaminase (U/L), serum glutamic pyruvic transaminase (U/L), lipid peroxidation (nmol MDA/g of Hb) and glutathione peroxidase (IU/gHb) (Table 4).

Table 4: Average fortnightly dry matter intake (g) by lambs fed diets various slow release non protein nitrogen products

Fortnight	Control	Urea ¹	FCU ²	CFCU ³	HMCCU ⁴	SEM	P value
1	607.4 ±46.67	580.0 ±58.75	574.6 ±53.65	593.2 ±56.49	576.2 ±29.77	20.963	0.98
2	629.5 ±40.43	581.7 ±36.06	572.6 ±63.88	588.1 ±47.19	650.9 ±49.44	20.851	0.74
3	654.9 ±28.12	616.0 ±33.58	662.3 ±40.52	647.6 ±33.90	714.8 ±37.16	15.667	0.40
4	699.5 ±15.42	664.5 ±30.59	692.0 ±44.40	687.3 ±34.29	724.8 ±35.62	14.352	0.78
5	747.3 ±8.06	703.8 ±36.63	729.4 ±66.16	746.0 ±42.67	751.2 ±58.70	19.791	0.94
6	769.0 ±7.39	724.6 ±38.33	738.8 ±59.06	767.4 ±39.99	747.1 ±59.67	18.998	0.94
7	816.0 ±13.71	758.4 ±26.26	760.7 ±55.07	805.0 ±25.06	799.5 ±53.25	16.558	0.75
8	810.6 ±13.00	751.5 ±22.69	758.4 ±50.51	799.4 ±26.34	802.8 ±51.16	15.70	0.68
Overall average dry matter	716.8 ±18.43	672.6 ±31.45	686.1 ±49.95	704.3 ±36.81	720.9 ±44.13	16.04	0.88

Each mean value is an average of 6 values.

¹ Urea contained 46% N and all other coated non protein nitrogen products contain 40% N.

² Fat coated urea.

³ Calcium salts of fatty acids coated urea.

⁴ Hydroxypropyl methylcellulose coated urea.

Inclusion of urea or SRU sources at around d¹1% of the total ration with better acclimatization to diets containing NPN sources for sufficient duration (e¹ 15days) of time could have resulted in no adverse effects on the blood biochemical parameters in present study. Kertz et al. (2010) observed that dietary inclusion of urea d¹1% did not have any negative effect on blood biochemical parameters in lactating cow while inclusion at 1.5, 2.0 and 2.5% of the diet increased the BUN, SGPT and SGOT concentration. Cherdthong et al. (2013) also reported that, inclusion of slow release urea greater than 1.5% of DM intake resulted in greater plasma urea nitrogen, glucose and total blood protein concentrations in beef cattle. The BUN (mg/dl) concentration in present study significantly (P<0.01) varied among the dietary groups with highest concentration in urea diet fed lambs, probably as a result of faster degradation urea to ammonia which resulted in more urea being produced in the liver. Xin et al. (2010) also reported higher BUN in feed grade urea fed cows compared to polyurethane coated urea and isolated soy protein fed cows. While the BUN concentration in present study was lower in the lambs fed with SRNPN sources and was comparable to the values of control group. In agreement with these findings, Sorathiyai and Fulsoundar (2011) also reported higher (P<0.01) BUN concentration in Surti buffalo heifers fed with 1% urea and lowest in control group fed with conventional diet. While, Gonçalves et al. (2015) observed no effect on plasma urea nitrogen levels when polymer coated slow-release urea replaced regular urea at different levels (0, 50, 80 and 100%) in the diet of beef steers. In contrast to above findings, Varlyakov et al. (2015) reported significant increase in total protein, albumin and albumin: globulin ratio and decrease in globulin level in rams when fed with 12g of Optigen compared to control group with no NPN source.

Cost economics

The cost of preparation of 1 kg total mixed ration was highest in control group (Rs. 17.41) due to higher market price of SBM, and the cost of preparation of urea based ration was lowest (Rs. 15.45) while, the cost of various SRNPN containing diets (Rs. 16.65 - 16.68) were intermediate between the control and urea diets (Table 6).

Table 6: Blood biochemical constituent and anti oxidant indices in growing lambs fed diets containing various slow release non protein nitrogen products

Constituent	Control	Urea ¹	FCU ²	CFCU ³	HMCCU ⁴	SEM	P	
							Value	Value
Glucose (mg/dl)	58.4±3.53	59.4±4.57	57.3±3.82	53.6±4.09	53.8±3.62	1.693	0.78	
Blood urea nitrogen (mg/dl)	23.5 ^{bc} ±1.92	30.8 ^a ±1.54	25.0 ^{bc} ±1.83	20.4 ^c ±0.57	26.8 ^{ab} ±2.65	0.993	0.01	
Total Protein (g/dl)	6.35±0.14	6.60±0.17	6.29±0.18	6.28±0.19	6.70±0.13	0.077	0.30	
Albumin (g/dl)	3.96±0.08	3.84±0.08	3.80±0.15	4.14±0.05	4.03±0.09	0.046	0.13	
Globulin (g/dl)	2.40±0.19	2.76±0.21	2.49±0.25	2.15±0.28	2.67±0.15	0.093	0.24	
Serum glutamic oxaloacetic transaminase (U/L)	24.8±1.12	26.7±2.68	23.4±1.03	24.2±2.48	25.0±0.32	0.849	0.12	
Serum glutamic pyruvic transaminase (U/L)	15.3±0.62	16.7±1.14	18.5±1.59	18.1±1.23	16.3±1.03	0.532	0.30	
Lipid peroxidation (nmol MDA/g of Hb)	61.3±3.09	62.3±2.78	59.8±3.56	61.2±2.94	60.9±3.05	3.112	0.92	
Glutathione peroxidase (IU/gHb)	164.5±9.82	171.2±10.34	158.8±8.92	168.4±10.11	164.2±10.59	10.281	0.82	

^{abc} Means bearing different superscripts in a row differ significantly: (P<0.05) Each mean value is an average of 6 values. ¹ Urea contained 46% N and all other coated non protein nitrogen products contain 40% N.; ² Fat coated urea; ³ Calcium salts of

Table 5. Feed conversion efficiency and average daily gain of growing lambs fed diet containing various slow release non protein nitrogen products

Attribute	Control	Urea ¹	FCU ²	CFCU ³	HMCCU ⁴	SEM	P
Dry matter intake (g per day)	702.4 ±17.53	663.3 ±29.22	676.6 ±48.06	681.8 ±36.81	713.0 ±43.21	16.81	0.84
Average dry matter intake (% of body weight)	3.46 ±0.11	3.50 ±0.16	3.53 ±0.12	3.51 ±0.11	3.61 ±0.14	0.055	0.95
Average dry matter Intake (g per kg *W ^{0.75})	70.0 ±1.45	69.0 ±2.36	69.5 ±1.89	70.4 ±1.92	71.7 ±2.59	0.881	0.91
Feed conversion ratio	5.43 ±0.24	6.02 ±0.56	5.79 ±0.34	5.58 ±0.41	5.85 ±0.42	0.184	0.72
Initial body weight (kg)	14.7 ±0.73	14.7 ±1.43	14.7 ±1.63	14.7 ±0.76	14.7 ±1.18	0.498	0.96
Final body weight (kg)	30.5 ±1.69	28.1 ±2.13	28.9 ±2.57	29.0 ±1.75	29.7 ±2.02	0.869	0.93
Total gain (kg)	15.3 ±1.01	13.4 ±1.50	14.2 ±1.17	15.1 ±1.20	14.8 ±1.17	0.531	0.69
ADG (g)	131.9 ±8.44	111.7 ±12.53	118.3 ±9.79	126.1 ±10.03	123.3 ±9.75	4.422	0.69

Each mean value is an average of 6 values, * Metabolic body weight

¹ Urea contained 46% N and all other coated non protein nitrogen products contain 40% N.

² Fat coated urea, ³ Calcium salts of fatty acids coated urea.

⁴ Hydroxypropyl methylcellulose coated urea.

Table 7. Cost of diets containing various slow release non protein nitrogen products

Ingredient	Cost of ingredients Rs/kg	Composition of complete diet							Cost of complete diet (Rs)							
		Control	Urea ¹	FCU ²	CFCU ³	HMCCU ⁴	Control	Urea ¹	FCU ²	CFCU ³	HMCCU ⁴	Control	Urea ¹	FCU ²	CFCU ³	HMCCU ⁴
Maize stover	10.0	48.4	50.7	50.6	50.6	50.6	484.0	507.0	506.0	506.0	506.0	506.0	506.0	506.0	506.0	506.0
Maize grain	15.0	32.3	36.1	36.0	36.0	36.0	484.5	541.5	540.0	540.0	540.0	540.0	540.0	540.0	540.0	540.0
Soybean meal	40.0	18.4	11.4	11.4	11.4	11.4	736.0	456.0	456.0	456.0	456.0	456.0	456.0	456.0	456.0	456.0
Mineral and vitamin mixture	100.0	0.3	0.3	0.3	0.3	0.3	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Salt	10.0	0.6	0.6	0.6	0.6	0.6	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Urea	5.0	-	0.90	-	-	-	-	4.5	-	-	-	-	-	-	-	-
FCU ²	118.0	-	-	1.10	-	-	-	-	129.8	-	-	-	-	-	-	-
CFCU ³	115.0	-	-	-	1.10	-	-	-	-	-	126.5	-	-	-	-	-
HMCCU ⁴	115.0	-	-	-	-	1.10	-	-	-	-	-	126.5	-	-	-	-
Cost per 100 kg complete feed		100.0	100.0	100.0	100.0	100.0	1740.5	1545.0	1667.8	1664.5	1664.5	1664.5	1664.5	1664.5	1664.5	1664.5
Cost per kg complete feed							17.41	15.45	16.68	16.65	16.65	16.65	16.65	16.65	16.65	16.65

¹ Urea contained 46% N and all other coated non protein nitrogen products contain 40% N.² Fat coated urea; ³ Calcium salts of fatty acids coated urea; ⁴Hydroxypropyl methylcellulose coated urea.

Table 8. Cost economics of feeding lambs with diet containing various slow release non protein nitrogen products

Attribute	Control	Urea ¹	FCU ²	CFCU ³	HMCCU ⁴	SEM	P value
Feed intake (g/day) (as fed basis)	770.2 ±23.76	727.3 ±39.99	746.6 ±59.79	755.8 ±45.92	781.4 ±47.43	18.98	0.93
Cost of total mixed ration/kg (Rs)	17.4	15.4	16.6	16.6	16.6	-	-
Cost of feed/day (Rs)	13.4 ±0.41	11.2 ±0.63	12.4 ±1.02	12.5 ±0.78	13.0 ±0.80	0.339	0.41
Average daily gain (g)	131.9 ±8.44	111.7 ±12.53	118.3 ±9.79	126.1 ±10.03	123.3 2±9.75	4.422	0.69
Cost of feeding per kg gain (Rs)	101.6 ±4.42	125.5 ±9.10	105.2 ±6.12	99.7 ±8.21	105.5 ±8.52	2.421	0.98

Each mean value is an average of 6 values.

¹ Urea contained 46% N and all other coated non protein nitrogen products contain 40% N.

² Fat coated urea, ³ Calcium salts of fatty acids coated urea, ⁴ Hydroxypropyl methylcellulose coated urea.

The daily cost of feeding lambs was lower in urea based group by 16.18 % compared to control group, while daily cost of feeding in FCU, CFCU and HMCCU groups was lower by 7.15, 6.19, 2.91%, respectively compared to that of control group. Though daily cost of feeding lambs was lower, the cost of feeding per kg gain was highest in urea group and it was higher by 23.52% compared to control group. While with feeding of FCU, CFCU and HMCCU diets the feed cost per kg gain was lowered by 16.18, 20.56 and 15.98%, respectively compared to feeding of urea based diet, which was due higher feed efficiency in SRNPN diet fed lambs compared to urea diet fed lambs (Table 1).

Saro et al. (2019) reported non significant difference in the feeding cost per day in Assaf lambs when fed with 1 and 2% urea compared to control. However authors reported significantly higher feeding cost per kg gain (€/lamb) in control (1.90) followed by urea1 (1.72) and lowest in urea 2 (1.71) groups. Similarly, Biradar et al. (2014) also reported lower feeding cost in urea treated finger millet straw fed group and 4% Optigen containing concentrate mixture fed group compared to control group (Finger millet straw and concentrate mixture).

CONCLUSION

The average daily gain and feed conversion ratio was lower in lambs with inclusion of urea at around 1% of dietary DM by 15.3 and 10.8% compared to control lambs. The ADG and FCR improved by 12.9 and 7.31% with total replacement of urea with CFCU and by 10.3 and 2.82% with HMCCU, respectively and reduced the feed cost per kg gain by 20.5 and 15.9%, respectively with no adverse effect on biochemical constituents.

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