Performance of Growing Lambs Fed Urea Ammoniated and Urea Supplemented Wheat Straw Based Diets

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ABSTRACT : Twelve growing male lambs (10.05±0.41 kg, 5 months age) were assigned to three equal groups in a completely randomized design and fed respectively wheat straw (WS), ammoniated wheat straw (AWS) or urea supplemented wheat straw (USWS) along with concentrate mixtures of varying protein and energy contents to meet their requirements as per NRC (1985). Despite comparable nutrient intake and digestibility, the lambs fed AWS based diet digested lower ($p<0.05$) crude protein. The digestibility of NDF and hemicellulose were lower while the digestibility of cellulose was higher in lambs on AWS as compared to lambs on USWS based diet. The lambs of all the three groups were in positive and comparable N, Ca and P balance except higher Ca balance in lambs fed WS based diet. The body weight change, average daily gain and feed conversion efficiency were similar among the dietary groups. All the parameters of rumen fermentation pattern were comparable between lambs of AWS and USWS based diets except ammonia-N concentration that was higher in the latter however it was lower in WS fed group. Though, the feeding cost per unit gain was comparable in lambs fed all the three diets, the cost incurred towards roughage during 120 days of experimental feeding was significantly less in lambs fed AWS than UTWS. Thus, feeding of USWS can be practiced to minimize labour cost and environmental pollution involved in the process of urea treatment without affecting the performance of growing lambs. *(Asian-Aust. J. Anim. Sci. 2001. Vol 14, No. 8 : 1078-1084)*

Key Words : Lambs, Ammoniation, Urea Supplementation, Wheat Straw, Intake, Nutrient Utilization, Rumen Fermentation, Cost of Live Weight Gain

INTRODUCTION

India possesses a sheep population of 44.8 million which is 4.12% of total of 1089.73 million (FAO, 1993). However, the shortage of good quality feeds and fodders along with poor genetic potential of these animals pose serious problem to reorient the sheep industry into an economic enterprise in our country. An estimated quantity of 417 million tones of crop residues are produced annually in India (Kosila, 1985). Effective utilization of crop residues like wheat straw, which has low nutritive value, poor palatability and poor digestibility, after economically viable chemical treatment or with suitable supplementation might provide possible strategies to overcome the existing chronic shortage for optimizing animal performance (Preston and Leng, 1984). Treatment of crop residues with urea, improved the palatability and digestibility of nutrients (Hart and Wanapat, 1992; Khan et al., 1999; Dass et al., 2000) as well as provide non-protein nitrogen (NPN) to ruminant diets (Jackson, 1977). The nutritive value of low-density roughages can be raised to that of medium quality hay by the use of ammonia treatment (Sundstol et al., 1978). Though, ammoniation has been considered the most practicable chemical method for improving the nutritive value of wheat straw (Birkelo et al., 1986). However, it is not clear whether this response was due to an increase in feed intake (Yadav and Yadav, 1986) and nitrogen content (Zhao and Cui, 1988) of the diet or to a change in the chemical structure of the straw arising from a reaction with NH_3 (Tuen et al., 1991). Moreover, environmental pollution and the labour involved in the process of ammoniation call for a fresh look into the subject in terms of comparative advantage, if any, over urea supplementation as such. The present study was thus conducted to compare the effects on growth, intake and nutrient utilization, rumen fermentation pattern and relative cost of feeding lambs with ammoniated wheat straw (AWS), with untreated wheat straw supplement ed with urea (USWS) immediately before feeding or with wheat straw (WS) alone.

MATERIALS AND METHODS

Preparation of feeds

Ammoniated wheat straw : Ammoniated wheat straw (AWS) was prepared following the procedure suggested by ICAR (1985). After 30 days of incubation, the required amount of AWS was aerated everyday for a period of 24 h prior to feeding to facilitate the escape of free ammonia.

Urea supplemented wheat straw : Urea supplemented wheat straw (USWS) was prepared daily in the morning at the time of feeding. The level of urea supplementation was decided to achieve a CP content almost nearer to AWS. For this, 100 ml of 15% urea solution (W/V) was added to each kg of wheat straw (WS). Uniform mixing of urea solution with WS was done manually before feeding.

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Concentrate mixtures : Two concentrate mixtures, A (control) and B (experimental), with varying CP and TDN levels were prepared (table 1) after considering the CP and TDN supplied by AWS/USWS.

Animals and feeding

Twelve growing male lambs (10.05±0.41 kg, 5 months age) purchased from local market were assigned to three equal groups in a completely randomized design after deworming, vaccination and acclimatization to the new environment for a period of one month. The lambs were housed individually in well ventilated cement floored shed having individual feeding facilities and reared under proper hygienic and uniform managemental conditions. All the animals were offered respective concentrate mixtures (Group 1 (control): Concentrate mixture A; Group 2 and 3 (experimental): Concentrate mixture B) at 09:30. throughout the 120 days of experimental feeding. Quantity of concentrate mixture was adjusted fortnightly as per body weight. The left over residue of each animal was weighed after 24 h consumption to arrive at daily total feed intake. Clean and fresh drinking water was provided *ad libitum* daily.

Metabolism trial

In order to study the digestibility and balance of nutrients, a metabolism trial of six days duration involving daily quantitative collection of faeces and urine and recording of feed and residue was carried out after 70 days of experimental feeding on all the animals by harnessing them in metallic metabolic cages. Representative samples of feed offered, residue left, faeces and urine voided were brought to the laboratory for further analysis.

Sampling of rumen liqour

At the end of experimental feeding about 100 ml of rumen liquor was collected from three representative animals from each group for three consecutive days at different hours (0, 3 and 6) postprandially through a stomach tube using little suction. Rumen liquor was strained (SRL) through multilayered cheese cloth and stored in a deep freeze after adding one drop of 10% mercuric chloride as a preservative. For recording of pH, about 50 ml SRL was taken in a separate conical flask.

Chemical analysis

Feed, faeces and urine samples : The proximate composition of feed and faecal samples was determined as per AOAC (1990) methods. The contents of neutral detergent fibre (NDF), acid detergent fibre (ADF) and cellulose were analysed using methods described by Van Soest et al. (1991). Hemicellulose content was calculated by subtracting ADF from NDF. The total carbohydrates (TCHO) fraction was arrived at by subtracting CP and EE from the organic matter (Sniffen, 1988). Nitrogen content in feed, faeces and urine was determined by micro-Kjeldhal method and crude protein calculated as N×6.25. Mineral extract of these samples were prepared (AOAC, 1990) and analysed for calcium as per Talapatra et al. (1940) and for phosphorus colorimetrically involving molybdovanadate reagent (AOAC, 1980).

Strained rumen liquor : The pH of rumen liquor was recorded using a pre-calibrated digital pH meter promptly after collection. The SRL was also analysed for total volatile fatty acids (TVFA) (Barnett and Reid, 1957), NH_3-N (Conway, 1957), total-N and trichloroacetic acid precipitable-N (TCA-ppt-N) (AOAC, 1990).

Statistical analysis

A completely randomized design was used to determine dietary effect. One way analysis of variance (ANOVA) was carried out on the experimental data using treatments as independent variable. The significance of difference between means was compared using Duncan's new multiple range test. However, data on rumen fermentation pattern were analysed using two way ANOVA and treatment means were compared by calculating critical difference as described by Steel and Torrie (1980).

RESULTS AND DISCUSSION

Chemical composition of straw

The CP content of wheat straw was found to be 3.87% (table 1) which is in agreement with the values reported by several workers (Kishan et al., 1984, Chhabra et al., 1987). Urea ammoniation increased the contents of CP, cellulose and ash while decreased the contents of total carbohydrates, NDF and lignin of WS. Similar results have been reported by several workers viz; increased CP and total ash (Cottyn and de Boever, 1988; Naik, 1997), increased cellulose (Singh and Gupta, 1985) and decreased total carbohydrates, NDF and lignin contents (Cottyn and de Boever, 1988).

Nutrient intake and digestibility

The intake of DM through conc. mix. and roughage (WS/AWS/SWS) was comparable among the groups. The roughage to conc. ratios were 40:60,44:56 and 41:59 in groups 1, 2 and 3 respectively. Though insignificant, the intake of roughage in group 2 intended to be higher (15-16%) than other two groups. The higher intake of straw due to ammoniation has been observed several workers (Jackson, 1977; Sundstol et al., 1978; Birkelo et al., 1986; Singh and Kishan, 1994) due to increased palatability and nutritive value. The digestible intake and digestibility of DM, OM and EE, were comparable among three groups except NDF and ADF digestibility which was significantly ($p<0.01$) lower and higher in group3, respectively as compared to group1 (table 2). This is in agreement with the

Table 1. Physical and chemica composition of feeds

Attributes	Conc. Mix. A (Control)	Conc. Mix.B (Experimental)	WS	AWS	USWS
Physical composition (per cent as fed basis)					
Ingredients					
Wheat bran	27	45			
Deoiled GNC	30	17			
Maize (crushed)	40	35			
Mineral mixture	2	2			
Common salt	1	1			
Vitablend AD_3 (g/100Kg)	25	25			
Chemical composition (per cent DM basis)					
Organic matter	91.9	90.2	88.9	87.1	89.9
Crude protein	21.6	18.9	3.9	7.7	8.3
Ether extract	2.6	2.9	0.9	0.9	0.9
NDF	29.7	31.5	79.2	76.7	80.6
ADF	9.2	11.1	55.9	54.5	56.9
Hemi-cellulose	20.5	20.4	23.3	22.2	23.7
Cellulose	6.0	8.7	43.7	46.1	45.3
ADL	3.2	2.4	12.2	8.4	11.6
Ca	1.4	1.0	0.3	0.3	0.2
P	0.7	0.8	0.1	0.1	0.1

GNC-Groundnut Cake; NDF-Neutral Detergent Fibre; ADF- Acid Detergent Fibre; ADL-Acid Digestible Lignin; Ca- Calcium; P- Phosphorus.

Table 2. Intake (g/day) and digestibility (%) of nutrients in growing lambs

Attributes	Group 1	Group 2	Group 3	SEM
Dry matter Intake, through				
Concentrate mixture A/B	310.4	304.4	303.3	10.29
WS/AWS/USWS	207.2	240.8	213.0	24.68
Total Intake	517.6	545.2	516.3	33.31
Digestibility	62.2	58.1	62.7	1.68
Organic matter				
Intake	469.0	478.3	465.6	29.78
Digestibility	64.9	59.2	64.3	1.77
Crude protein				
Intake	73.9	76.2	75.3	3.68
Digestibility**	61.2[b]	50.8[a]	66.2[b]	1.76
Ether extract				
Intake	10.2	10.9	10.7	0.50
Digestibility	82.0	80.4	86.1	1.91
Total carbohydrates				
Intake	384.9	396.8	379.6	25.69
Digestibility	65.1	60.8	63.3	1.88
NDF				
Intake	261.0	282.0	262.2	23.23
Digestibility**	51.4[b]	48.5[b]	43.2[a]	0.89
ADF				
Intake	147.9	162.6	150.4	15.82
Digestibility**	38.6[a]	40.3[ab]	44.4[b]	1.12
Cellulose				
Intake	108.2	115.4	123.1	12.15
Digestibility*	52.2[ab]	49.3[a]	54.8[b]	1.18
Hemicellulose				
Intake	113.2	119.4	111.8	7.52
Digestibility*	71.9[c]	59.6[b]	41.9[a]	2.82

Mean values with different superscripts in a row differ significantly: *$p<0.05$; **$p<0.01$.

results of Singh and Kishan (1994) in buffaloe, calves and Singh and Kishan (1983) in goats. Conversely other workers reported significant improvement in DM intake due to urea-ammonia treatment (Brand et al., 1992, Bruchem et al., 1993) and urea supplementation of straws (Mbatya et al.,1983 and Cloete and Kritzinger, 1984). Significantly ($p<0.01$) higher NDF digestibility in lambs fed AWS diet might be due to an alkali effect on the cell walls by releasing aromatic compounds (Cloete and Krizinger, 1984; Djajanegara and Doyle,1989) and possibly owing to the associated cell wall sugars (Chesson, 1981). However, ADF digestibility was significantly higher in groups 2 and 3 as compared to control group 1. This is because of urea ammoniation and urea supplementation of wheat straw by which conc. of NH_3 in SRL was maintained amply. Similarly the enhanced digestibility of fibre fraction was observed in sheep (Djajanegara and Doyle., 1989) and in buffaloes (Singh and Kishan., 1994) fed on urea ammoniated or urea supplemented straw. The deficit in CP intake through conc. in group 2 and 3 was compensated by the higher CP content of AWS or USWS, hence the CP intake was comparable among 3 groups. However, digestibility of CP was significantly lower ($p<0.05$) in group 2 than group 1 and 3. This may be attributed to either tightly bound N in the straw by urea-ammoniation (Sundstol, 1984, Hvelplund, 1989) or increased nitrogen flow to the intestine owing to greater microbial protein synthesis in the rumen (Djajanegara and Doyle, 1989).This corroborated well with the findings of Cloete and Kritzinger, 1984; Gupta et al., 1988; Singh and Kishan, 1994. Contrary, Borah et al. (1988) found increased CP digestibility in animals fed ammoniated straw.

Table 3. Body weight gain, feed conversion efficiency and plane of nutrition in lambs

Attributes	Group 1	Group 2	Group 3	SEM
Body weight gain				
Initial body weight (kg)	10.0	10.0	10.1	0.72
Final body weight (kg)	19.3	19.8	20.5	1.27
Days in experiment	120	120	120	
Total weight gain (kg)	9.3	9.8	10.4	0.77
Average daily gain (g)	77.8	81.3	86.5	6.40
Feedconversion efficiency(FCE)				
Total DM intake (kg)	56.9	63.5	57.6	3.59
Total weight gain (kg)	9.3	9.8	10.4	0.77
FCE	6.2	6.6	5.5	0.27
Plane of nutrition (during trial period)				
Metabolic body weight ($W^{0.75}$kg)	7.8	7.7	7.8	0.38
Nutrient intake ($W^{0.75}$kg)				
Dry matter	66.1	70.8	66.3	2.03
Crude protein	9.4	9.9	9.7	0.15
Digestible crude protein**	5.8 [b]	5.0 [a]	6.4 [c]	0.13
TDN	40.2	38.2	38.4	0.92
Nutritive value of diets (%)				
DCP	8.7	7.1	9.6	--
TDN	60.7	54.9	59.9	--

Mean values with different superscripts in a row differ significantly: **p<0.01.

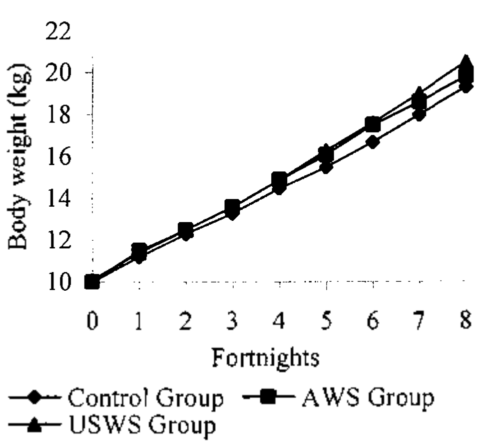

Figure 1. Fortnigntly body weight change in lambs

Feed conversion efficiency, body weight gain and plane of nutrition

Feed conversion efficiency, body weight gain and plane of nutrition is given in table 3. The lambs fed on either WS, AWS or USWS based diets required 6.2, 6.6, and 5.5 KgDM per Kg gain, respectively, the differences being statistically non-significant. The observed FCE values were close to the values 6.5 and 5.5 as reported by Bhadur and Bhat (1981) in Muzaffarnagari sheep and their crosses with Corridales, respectively. The ADG of lambs in groups 1, 2 and 3 was comparable and ranged from 77.8 to 86.5 g/day (figure 1). The observed range of ADG on three diets was in agreement to the findings of Prakash et al. (1990) where Muzaffarnagari lambs were fed on a diet consisting of 60% concentrate mixture and 40% green fodder. The anticipated ADG of 100 gm could not achieved due to 5-10% lower intake of CP and TDN as required by the NRC (1985). The intake of DM , CP and TDN per kg metabolic body size ($W^{0.75}$) was comparable among groups except DCP intake, which was lower (p<0.05) in group 2 and 3. The DCP

Table 4. Balance of nutrients in different experimental groups

Attributes	Group 1	Group 2	Group 3	SEM
Nitrogen (g/day)				
Intake	11.82	12.19	12.04	0.59
Excretion: Faecal*	4.60[ab]	6.01[b]	4.10[a]	0.38
Urinary	2.64	1.82	2.51	0.42
Absorbed*	7.22[b]	6.19[a]	7.94[b]	0.33
Balance	4.57	4.40	5.43	0.43
Calcium (g/day)				
Intake**	5.05[b]	4.01[a]	3.59[a]	0.18
Excretion: Faecal	2.95	3.47	3.09	0.32
Urinary	0.03	0.04	0.04	0.01
Balance**	2.07[b]	0.51[a]	0.45[a]	0.19
Phosphorus (g/day)				
Intake	2.44	2.58	2.48	0.10
Excretion: Faecal	2.11	1.95	1.99	0.14
Urinary	0.04	0.04	0.04	0.01
Balance	0.29	0.59	0.45	0.07

Mean values with different superscripts in a row differ significantly: *p<0.05; **p<0.01.

Table 5. Feed cost of liveweight gain (FCWG) in growing lambs

Attributes	Group 1	Group 2	Group 3	SEM
Intake (kg DM)				
Concentrate mixture(A/B)	35.3	35.7	35.6	1.11
WS/AWS/USWS	21.7	27.8	22.0	2.57
Total	56.9	63.5	57.6	3.59
Cost of feed (Rs)				
Concentrate mixture(A/B)	237.8	211.7	211.1	6.70
WS/AWS/USWS*	28.8[a]	43.6[b]	30.1[a]	3.55
Total	266.6	255.4	241.2	9.97
Total liveweight gain (kg)	9.3	9.8	10.4	0.77
Cost per kg gain (Rs)	28.9	26.4	23.4	1.47
Relative feed cost	100	91.4	81.0	--

Mean values with different superscripts in a row differ significantly: *p<0.05.

Cost of feed as per financial year 97-98 (Rs. kg $^{-1}$). Maize, 5.40; Wheat bran, 4.00; Ground nut cake, 9.20; Mineral mixture, 9.00; Salt, 2.00, Wheat straw, 1.20; Urea 3.50.

contents of WS, UTWS or USWS diets were 8.7, 7.1 and 9.6% respectively and for TDN corresponding values were 60.7, 54.9 and 59.8%. The lowered DCP and TDN of AWS based diet might be attributed to higher percentage of roughage in the diet resulting in lower digestibility of the nutrients. The intake of DM , CP and TDN was comparable to the stipulated requirements of NRC (1985) for similar body weight gain.

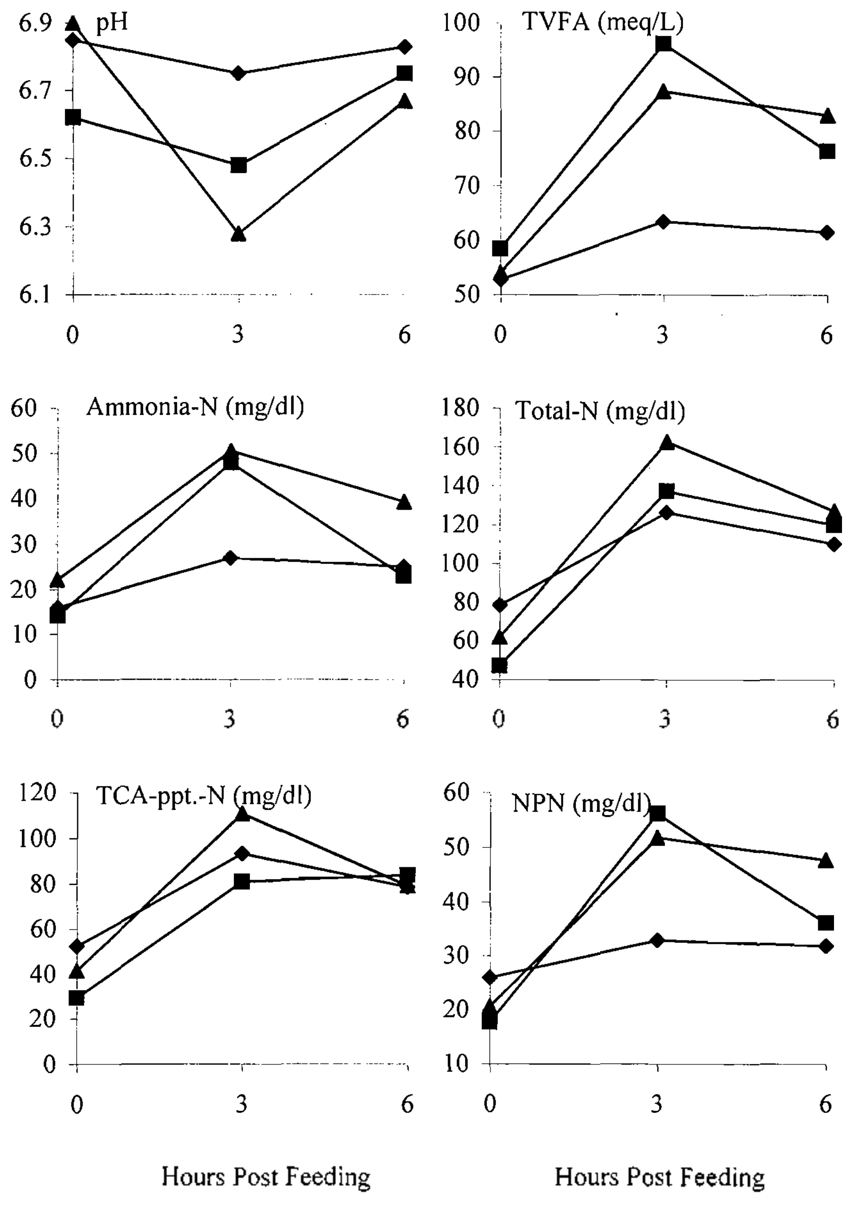

Figure 2. Rumen fermentation pattern in lambs fed AWS/USWS based diets

Balance of Nutrients

The intake of N was comparable among 3 groups but due to significantly lower CP digestibility in group 2, the amount of N absorbed was lower ($p<0.05$) in group 2 than 1st and 3rd. However, there was no significant difference in N balance among 3 groups. It indicated that absorbed N was efficiently utilized due to higher total volatile fatty acids (TVFA) concentration in SRL in group 2 as also evident from lesser N excretion through urine (table 4). The increased feacal N excretion in group 2 (AWS) might be due to of liquified protein (Sundstol, 1984, Hvelplund, 1989 and Djajanegara and Doyle, 1989). This contention holds good in the light of observations reported by Romero et al. (1976), Mehra et al. (1983), Dahiya and Mudgal (1992) and Singh and Kishan (1995).

The intake of Ca was higher ($p<0.01$) in group 1st as compared to group 2 and 3 owing to higher Ca content in conc. mixture (table 1). The higher Ca intake in group 1st resulted in higher ($p<0.01$) Ca balance. Moreover, even at lower intake in group 2, the excretion of Ca through faces was higher owing to alkaline pH of intestine by feeding AWS. Similar results were reported by Singh and Kishan (1994) in buffalo calves fed on AWS/USWS. However, similar intake and excretion of phosphorus resulted a comparable balance among all 3 groups. The Ca:P ratio in the diets was 2:1, which is optimum for efficient Ca and P utilization (McDonald et al., 1995)

Rumen fermentation pattern

The Rumen fermentation pattern in lambs fed WS/AWS/USWS based diets is given in figure. 2. The pH of SRL (6.79) was decreased to 6.50 at 3 h and again increased to 6.75 at 6 h post feeding. Among dietary treatments, control group 1st had higher ($p<0.05$) ruminal pH. However, the highest TVFA and NH_3-N conc. in SRL coincided with the lowest pH in group 2. It has been reported by Phillipson (1982) that pH is inversely proportional to TVFA conc. and directly proportional to NH_3-N conc. in SRL. Similarly, a large variation in ruminal pH (6.2 to 7.0) was observed by Rihani (1993) under different method of urea supplementation.

The observed higher ($p<0.01$)TVFA conc. at 3h and 6h post feeding was an indication of enhanced fermentation. Results showed that uniform distribution of urea/feeding of AWS helped in efficient utilization of soluble-N by the rumen microbes. Similar results were obtained by Dahiya and Mudgal (1992), Singh and Kishan (1995).

The NH_3-N and NPN concentration was higher ($p<0.01$) in group 3rd as compared to group 1. The peak point was at 3 h post feeding. The higher availability of NPN in AWS/USWS might have resulted higher NH_3-N concentration in groups 2 and 3. This is in agreement with the observations reported by Puri and Gupta (1990), Dahiya and Mudgal (1991), Singh and Kishan (1995).

Feed cost of live weight gain

The feed cost of live weight gain (FCWG) is largely dependent on cost of feed and efficiency of feed utilisation. Though, the total cost of feed consumed was the lowest in lambs fed USWS based diets (Rs. 242.2) as compared to AWS (Rs. 255.40) or WS (Rs. 266.60) based diets (table 5). But these were statistically comparable. However, the roughage cost of feed was significantly higher in AWS based diets owing to the use of higher amount of urea as well as labour cost incurred during ammoniation. The feed cost per kg gain was minimum in group 3 though, the differences were insignificant.

CONCLUSION

In the current study it was observed that the performance of growing lambs among three groups was comparable. Hence urea supplementation (USWS) of wheat straw in lieu of urea ammoniation can be used as a handy and wholesome method which will ultimately eliminate labour cost involved in and environmental pollution arising out of the latter process without affecting the performance of lambs.

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