Dept. of Animal Production,
Fac. of Agriculture, Assiut Univ.

EFFECT OF UREA ADDITION TO SHEEP DIETS ON DIGESTABILITY, N BALANCE, GROTH RATE and FEED EFFICIENCY.

(With 4 Table and one Fig)

By

S.M. MOUSA

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تأثير اضافة اليوريا فى علائق الأغنام على الهضم وميزان الأزوت ومعدل النمو وكفاءة التحويل الغذائيه

سليمان مصيلحى موسى

أجريت هذه الدراسة لمعرفة أثر اضافة اليوريا الى العليقة الأساسية (٣ر١٠٪ بروتين خام) على هضم المركبات الغذائيه وميزان الأزوت ومعدل تغير وزن الجسم وكفاءة التحويل الغذائية وكذلك كمية المياه التى يشربها الحيوان يومياً. استخدمت ثلاث معدلات من اليوريا ١ ، ٥ر١ ، ٢٠٪ من الماده الجافه وأجرى عليها تجارب هضم ونمو. أربعة تجارب هضم وميزان أزوت استخدم فيها ٨ حملان أوسيمى فى عمر سنه واحده وتجربة نمو استخدم فيها ١٢ حمل أوسيمى نامى عمر ٤ شهور. أوضحت نتائج هذه التجارب أن هضم البروتين الخام والألياف الخام تحسنت بأضافة اليوريا الى العليقة الأساسيه وكان معدل التحسن فى هضم البروتين ٤ر١٢ وحده مئويه وكان التحسن فى هضم الألياف ٦ر١٥ وحدة مئويه. زيادة النيتروجين المحتجز بالجسم وذلك بزيادة اضافة اليوريا الى العليقة فكانت حوالى ١٤ وحده مئويه زيادة فى الأزوت المحتجز تم الحصول عليها بالتغذيه على العليقة التى تحتوى على ٢٪ يوريا. معدل الزياده فى الوزن كان اعلى فى العليقه التى احتوت ٢٪ يوريا عن العليقه الأساسيه بحوالى ٤٥٪. معدل استهلاك الغذاء لكل كيلو جرام نمو أقل فى العليقة المرتفعه فى اليوريا عنها فى عليقة الكنترول. كما أوضحت النتائج أيضاً أن هناك زياده تدريجيه فى كمية المياه اليوميه التى يشربها الحيوان رغم أن هذه الزياده لم تكن معنويه الا أنها كانت أعلى فى علائق اليوريا عن الكنترول ١ر٥ ، ٩ر٥ ، ٩ر١٦٪ بالترتيب. كان هناك فروق معنويه (١٪) فى كمية المياه المستهلكه بين الحيوانات وكذلك الأيام التى تم فيها حساب كمية المياه المستهلكه. من النتائج السابقه يتضح أن أضافة اليوريا الى العلائق الأساسيه ترفع من معدل الهضم لكل من البروتين الخام والألياف الخام وكذلك يزيد من معدلات النمو للأغنام وبالتالى فأن اضافة اليوريا الى العلائق التى تحتوى على مواد علف ذات قيمه منخفضه يرفع من قيمتها الغذائيه.

SUMMARY

effect of urea addition to the basal diet (10.3 % CP) on nutrients digestibility, N balance, body weight changes, feed efficiency as well as water intake was investigated in the present study. Three urea levels (1, 1.5 and 2 % of diet DM) were added to the basal diet. Digestibility and growth studies were conducted to achieve the objectives of the present study. Four digestibility and N balance studies were conducted using 8 Ossimi rams (one year old). A growth study using 12 growing Ossimi rams was conducted too. The results of these studies indicated that, digestibility of both CP and CF was increased gradually by urea addition to the basal diet from 59.4 to 71.8 and from 38.5 to 53.1 % for CP and CF, respectively. Nitrogen retention increased gradually when urea was added at level of 2 % to the basal diet by about 14 % units. Daily gain was about 11, 20 and 45 % higher ($P<0.05$) in rams fed diet B, C and D (urea containing diets), respectively than that fed diet A (urea free diet). The consumed feed as Kg/Kg gain was lower in diets B, C and D than that of diet A. Results also, indicated that there was a tendency for increasing water intake with increasing urea level in the diet. Although, the differences were not significant but was 5.1, 5.9 and 16.9 % higher in diets containing urea than that of basal diet. The results also indicated that effect of animals and days on water intake was significant ($P<0.01$). It could be concluded that urea addition to the basal diet improved the CP and Cf digestibility, increased the N retention, and improved the feed efficiency, a matter which could be advised from the economical point of view.

INTRODUCTION

The addition of nitrogen (N) to the ruminants diets could improve the voluntary consumption of food (*CAMPLING* et al., *1962*; *HADJIPANAYIOTOU* et al., *1975* and *UMUNNA, 1982*). This improvement may be due to improving the nutritional environment of the rumen which in turn would stimulate microbial proliferation and activity microorganisms leading to enhancement of dry matter digestibility (*UMUNNA, 1982*).

Urea is the major source of N supplement in ruminant diets. In addition to its uses as a N source, it has some other benefits. The second one is its effect on pregnancy. Different studies indicated that the addition of urea to molasses increased the pregnancy frequencies by 8 to 10 % in cows (*HODGES* et al., *1974* and *PATE* et al., *1990*). The third benefit is obtained by decreasing dietary protein degradability in the rumen and so increase its bypass to the small intestine (*ELLIOTT* and *ARMSTRONG, 1982*). The addition of urea or spraying urea based liquid to hay before feeding increased the digestibility of both organic matter (OM) and dry matter (DM) (*FISHWICK,* et al., *1978* and *UMUNNA, 1982*).*UMUNNA, and DANKINAFO (1978)* found that within limits N digestibility parallels N intakes, beside improving the N retention in the body (*ELLIOTT and ARMSTRONG, 1982).*

The object of this study was to throw some light on the effect of urea addition to ruminant diets having low protein level on digestibility, N retention, growth rate and feed efficiency as well as daily water intake.

MATERIALS AND METHODS

Four digestibility trials were conducted to test the effect of urea addition to the low protein diet (10.3 % CP) on nutrients digestibility and N retention, beside growth study to determine the effect of urea addition on growth rate, feed efficiency and daily water intake.

Diets :

To meet the CP requirement for growing lambs as stated by *CHURCH (1984)*, three urea levels (1, 1.5 and 2 % urea) were added to the basal diet. Urea was mixed with 10 % ground corn then handily mixed with ground feed mixture. Corn was used as a urea carier and also to provide available carbohydrates for NPN as recommended by *CONRAD and HIBBS (1968)*. They stated that for every 100g of urea one Kg of readily fermented carbohydrate is needed for adapted cow feeds. Feed composition is shown in table 1. Wheat straw weighed daily and mixed with concentrates as shown in table 1. Each ration was fed twice daily. Water was available all the day. Diets containing urea were introduced to experimental animals gradually in portions during the adaptation period to avoid any toxicity problems and to allow microorganisms in the rumen to get adapted to new diets.

Digestibility trials:

Four digestibility trials using 8 Ossimi rams (35 Kg average body weight) were undertaken to determine the feeding value as well as the digestion coefficients of whole mixtures used in the present study. Nitrogen balance was determined for each feed mixture.

Doublicate adults rams (one year old) were used in each trial, following the usual procedures using metabolic cages. The same rams were used in every study. The sequence of the digestibility trials was the control (urea free diet), diet B (1 % urea), diet C (1.5 % urea) then diet D (2 % urea). The duration of the study was 21 days as adaptation period, followed by 10 days prelimenary period then 10 days collection period for diet B. The adaptation period for diet C and D was reduced to 7 days only. This because each diet was used as an adaptation for the other diet. The control diet did not have an adaptation period.

Groth study:

Twelve Ossimi rams (four months old) were divided into four groups and randomly distributed to the tested diets. The duration of the study lasted for 5 months preceded by 21 days as an adaptation period. Rams were weighed every other week for two days to the nearst kilogram. Feed efficiency was calculated for each group.

Samples and analysis:

Samples of mixed feed was taken for chemical analysis at the beginning of the collection period of the digestibility study. During the collection period total daily fecal output was collected from each ram, 10 % sample was taken, dried at 60 °C in a forced air oven for 48 hours. Dry samples were mixed. Feed samples and dry feces were ground through a Willy mill with a 2mm screen. Dry samples were kept in plastic vials at room temperature for the chemical analysis. Total daily urinary excretion from each ram was collected in a jar containing 50 ml of 10 % H_2SO_4 to prevent ammonia loss. A daily samples of 10 % was taken from each ram, kept frozen till the time of analysis.

Water was offered three times a day at 9am, 1pm and 5pm. Daily water intake was easured during the second month of the study after the adaptation period.

The dry matter of feed and feces were determined after drying in a forced air oven at 100 °C for 24 hours. Ash was determined by placing samples in muffle furnace at 600 °C overnight. Fat and crude fiber (CF) content of the same samples were determined as explained by the *A. O. A. C. (1975)*. Total N content of feed, feces and urine was determined using Kjeldahl procedure (*A. O. A. C., 1975)* as modified by *STERN and SATTER (1984)*. Nitrogen free extractives (NFE) were obtained by differences.

Statistical Analysis:

Results were subjected to analysis of variance for comlete randomized design (CRD) as expalined by *COCHRAN and COX (1957)*. The statistical model for the CRD was:

$Y_{ij} = U + T_i + E_{ij}$

where :

Y_{ij} = The value of the dependent variable for the ith treatment.

U = Common mean.

T_i = Treatment effect i= 1-4.

E_{ij} = Random error.

For the water intake measurements, animals and days effects were included in the equation.

Mean separation was conducted using the SNK procedure as explained by *SOKAL and ROHLF (1981)*.

RESULTS

Feed ingredient and chemical composition of diets are illustrated in table 1. Addition of urea to the basal diet increased the CP content by 2.4, 3.3 and 4.7 % units for diets B, C and D, respectively. The other nutrients were almost the same in all diets except for NFE which was ranged from 58.1 to 53.8 % for diets A to D. The TDN value of the diets were the same while digestible crude protein (DCP) was different among diets.

Digestion coefficients of all nutrients in the studied diets are shown in table 2 and Fig. 1. Digestibility of CP and

CF were affected by urea addition to the basal diet (A). They were gradually increased by urea addition from 59.4 to 71.8 and from 38.5 to 53.1 % for CP and CF, respectively. The other affected nutrient was NFE which did not have any clear trend because it was calculated by differences in both feed intake and fecal material output.

Nitrogen metabolism data are shown in table 3. Addition of urea to the basal diet decreased the fecal N output as a percentage of total intake while it increased urinary N for diets B and C only. Nitrogen retention increased gradually when urea was added to the basal diet by about 14 % units higher at level of 2 % urea.

Body weight changes; feed efficiency and daily water intake are present in table 4. There was no significant differences in initial body weight. There was a significant differences ($P<0.05$) among treatments in final body weight, daily gain and feed consumed/Kg gain. Daily gain was about 11, 20 and 45 % higher in rams fed diet B, C and D, respectively than those fed diet A (urea free diet). On the other hand, the consumed feed as Kg/Kg gain was 16, 10 and 31 % lower in rams fed diet B, C, and D than those fed diet A. Data in the same table indicated that there was a tendency for increasing water intake with increasing urea level in the diet. Although, the differences were not significant but was 5.1, 5.9 and 16.9 % higher in diets containing urea than that of the urea free diet. The results also indicated that animals and days differences were significant ($P<0.01$).

DISCUSSION

Addition of urea increased the CP content of the basal diet as well as digestible crude protein (DCP) in all diets. Because urea addition has an effect on CP digestibility (table 2) the change in DCP was not as that of CP. Digestibility was calculated in the whole diet to be sure that the associative effect aamong feed ingredients is included in the calculation. The improvement of apparent CP digestibility in diets B, C and D, (urea containing diets) obtained in the present study may be due to a) urea provide suitable N level for rumen microorganisms to synthesis of microbial protein (*OWEN and BERGEN, 1983)* which in turn improve digestibility. b) Mathematically, N digestibility is proportional to N intake across a wide variety of deits (*OWEN and BERGEN, 1983)*.and c) Because metabolic fecal N (MFN) is proportional to DM but not to CP intake, therefore, its proportional in the total fecal N is reduced and hence increased calculated

apparent CPD. This trend agrees with that previously reported by *BARTH* et al. *(1974)* who found that increasing of total N as urea from 24 to 48 % resulted in a significant increase in CPD ($P<0.05$). *UMUNNA (1982)* found that addition of urea to basal hay improved DM, OM and N digestibility. He also added that the improvement in CPD was about 20 % units while it was only 4 % units in DMD. The same results were obtained by *WINDSHITL and STERN (1988)*. Recently, *WILLMS* et al. *(1991)* found that, digestion coefficient was higher when lambs were fed diets containing 50% urea than either of control (SBM diet) or diets contained 17 and 33% urea.

Apparent digestibility of CF was improved by addition of urea to the basal diet (38.5 to 53.1 %). This because rumen microorganisms convert urea to ammonia, celluolytic bacteria prefere ammonia for their protein synthesis *(HUBER, 1976)*. Also they utilize NH_3-N as their principle N source *(ALLISON, 1980)*. Ammonia also helps to keep the rumen pH in a desirable range for cellulose digestion *(OWENS and BERGEN, 1983)*. Therefore, NH_3-N provided as a results of the higher level of urea supplementation may have stimulated cellulolytic activity. The same results were obtained by *DAUGHERTY and CHURCH (1982) and VARGA* et al. *(1982). ABD EL-HAFIZ and EL-HOMMOSI (1982)* diet that increasing the percentage of N as urea in the diet, resulted in an increase in digestion coefficients of nutrients especially the crude fiber. *WINDSCHITL and STERN (1988)* found same results in their study. In an in vitro experiment, they found that the addition of urea to the basal diet to cover up to 30 % of total N input improved ADF digestibility (25 to 47.8%), cellulose (26.2 to 52.0 %) and total nonstructural carbohydrates. Recently *HSU* et al. *(1991)* replaced 30 % of SBM nitrogen with urea N for defaunated sheep, and found that urea increased the total tract digestibility of DM, OM and ADF. Figure 1 indicated that the digestibility of the other nutrients was decreased when 1 % urea level was used and then increased gradually at other levels. This may be due to the insufficiency of the adaptation period for the first period. *CONRAD and HIBBS (1968)* reported an adaptation period ranged from 19 to 50 days in their trials.

Nitrogen metabolism results showed that the addition of urea to the basal diet improved the N retention in the body either as g/day or as % of total N intake. This improvement may be due to the increasing of the microorganism proliferation in turn increase the utilization of other feed nutrients. It also could be attributed to keeping metabolic fecal N output

constent. *ABD EL-HAFIZ and EL-HOMMOSI (1982)* found that when urea N replaced 20 and 40 % of the total diet N fecal N decreased in the higher level. They also found that percentage of N retention increased only with diet containing 20 % N from urea. urinary N was higher in diet B (1 % urea) than all other urea containin diets. This may be due to insufficient adaptation period. Addition of urea to the basal diet increased the urinary N output as g/day, the same results were obtained by *ABD EL-HAFIZ and EL-HOMMOSI (1982). OWENS and BERGEN (1983)* indicated that postrumenal adminstration of NPN may be useful because it often increases N retention. This may be due to cycling of N to the rumen or large intestine to meet dificiencies at these points.

Table 4 indicated that urea addition increased daily gain. This may be due to the higher protein intake as well as improved nutrient digestibility as shown in table 2. These results also associated with that of table 4 where N retention was about 7 and 14.3 % units higher in diets C and D, respectively than that of the control one (diet A). Early study by *ORSKOV* et al.*(1971)* indicated that when the CP of the diet fed to lambs weighing between 20-40 Kg increases from 8-10 % to 16-18 % (on a DM basis) their growth rate increases. *ABD EL-HAFIZ and EL-HOMMOSI (1982)* indicated that there was a slight increase "nonsignificant" in average daily gain in diets containing 20 and 40 % of total N as urea comparing with the control.

Water intake increased with increasing urea level in the diet. This because addition of urea raises the N content of the diet which increased urinary excretion and as a result water consumption *(BONDI, 1987).* The same author indicated that urea is the major protein catabolism in the body, it requires much water to be diluted in urine.

Previous study by *MOUSA and IBRAHIM, (1991)* indicated that 1.5 % urea is the best level for dairy cattle while in the present study 2 % urea is found to be better than the other level for lambs. Also, *WILLMS* et al. *(1991)* found that digestibility improved when urea replaced 50 % of diet N. Finally, it could be concluded that urea can be added to the low quality roughage in mixed diet to improve CP and CF digestibility, N retention and body weight changes. Also, urea level can not be fixed for all species and assumed to be less

than 30 % of the CP in the diet (37 % in the present study and 50 % in the *WILLMS* et al. (*1991*) study).

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REFERENCES

Abd el-Hafiz, G.A. and El-Hommosi, F.F. (1982): The value of urea as a nitrogen source in fattening rations containing bagasse, for lambs. Assiut Vit. Med. J. 17&18: 40-46.

Allison, M.J. (1980): Nitrogen requirements of ruminal bacteria. In. F.N. Owens (Ed.) Proc. Int. Sympo. Protein Requirements for Cattle. pp 128-132. Oklahoma State Univ., Stillwater.

A.O.A.C. (1975): Official methods of analysis (12th. Ed.) Association of official analytical chemists, Washington, D.C.

Barth, K.M.; Corrick, J.A.; Shumway, P.E. and Coleman, S.W. (1974): Effect of level of urea and urea plus limestone on N.metabolism of corn silage baseed rations by cattle. J. Anim. Sci. 38: 687-694.

Bondi, A.A. (1987): "Animal Nutrition" John Willy and sons. New York.

Cochran, W.G. and Cox, G.M. (1957): Experimantal Designs. 2nd. Jhon Wiley & Sons. New York.

Campling, R.C.; Freer, M. and Balch, C.C. (1962): Factors affecting the voluntary intake of food by cows. 3. The effect of urea on the voluntary intake of oats straw. British J. of Nutrition 16: 115-124.

Church, D.C. (1984):" Livestock Feeds and Feeding" 2nd Ed. pp 339-353. O&B Books, Inc. Oregon. USA.

Cone, J.W.; Cline-Theil, W.; Malestein, A. and Klooster, A.T. (1989): Degradation of starch by incubation with rumen fluid. A comparison of different starch sources. J. Sci. Food Agric. 49: 173-183.

Conrad, N.R. and Hibbs, J.W. (1968): Nitrogen utilization by ruminants. Appreciation of its nutritive value. J. Dairy Sci. 51: 276-285.

Daugherty, D.A. and Church, D.C. (1982): The in vivo and in vitro evaluation of feather meal and hair meal with urea for ruminants. J. Anim. Sci. 54: 345-352.

Elliott, R. and Armstrong, D.G. (1982): The effect of urea and urea plus sodium sulphate on microbial protein production in the rumens of sheep given diets high in alkali-treated barley straw. J. Agric. Sci. (Camb.) 99: 51-59.

Fishwick, G.; Parkins, J.J.; Hemingway, R.G. and Ritchie, N.S. (1978): A comparison of the voluntary intake and digestibility by beef cows of diets based on oats straw and supplemented with different forms of non-protein nitrogen. Anim. Prod. 26: 135-141.

Hadjipanayiotou, M.; Louca, A. Lawlor, M.J. (1975): A note on the straw intake of sheep given supplements of urea-molasses, soybean, barley-urea or barley. Anim. Prod. 20: 426-432.

Hill, G.M.; Utley, P.R. and Newton, G.L. (1987): Dietary urea influences on digestibility and utilization of diets containing peanut skins by steers. J. Anim. Sci. 64: 1-7.

Hodges, E.M.; Peacock, F.M.; Chapman, Jr. H.L. and Green, R.E..L. (1974): Forage and supplement systems for beef cows in south-central Florida. Proc. Soil Crop. Sci. Florida. 33: 56-66.

Hsu, J.T.; Fahey, Jr. G.C.; Clark, J.H.; Berger, L.L. and Merchen, N.R. (1991): Effects of urea and sodium bicarbonate supplementation of a high-fiber diet on nutrient digestion and ruminal characteristics of defaunated sheep. J. Anim. Sci., 69: 1300-1311.

Huber, J.T. (1976): Use of non-protein nitrogen by lactating cow. Feedstuffs 48: 13-14.

Kumar, R. and Snigh, M. (1984): Recovery from tannic acid-inhibited proteolysis in the rumen by urea. Indian J. Anim. Sci. 45: 438-441.

Mehrez, A.Z. (1989): Associative effects of feeds. Proc. First scientific symposium on animal and poultry nutrition. Assiut University, 15-16 Nov. 1989. Assiut, Egypt.

Mousa, S.M. and Ibrahim, E.M. (1991): Effect of urea addition to dairy cattle ration, with low protein contents, on milk yield, composition and some technological properties. Assiut J. Agric. Sci. 22: 179-196.

Orskov, E.R.; I. McDonald, C. Fraser and E.L. Corse. (1971): Agric. Sci. 77: 351-359 (CF Churchu, 1984).

Owens, F.N. and Bergen, W.G. (1983): Nitrogen metabolism of ruminant animals: Historical perspective, current understanding and future implications. J. Anim. Sci. 57 (Suppl. 2): 498-518.

Pate, F.M.; Sanson, D.W. and Machen, R.V. (1990): Value of a molasses mixture containing natural protein as a supplement to brood cows offwered low-quality forages. J. Anim. Sci. 68: 618-628.

Sokal, R.R. and Rohlf, F.J. (1981): "Biometry" 2nd ED. W.H. Freeman and Company, San Francisco. pp 244.

Stern, M.D. and Sater, L.D. (1984): Evaluation of nitrogen solubility and dacron bag technique as methods for estimating protein degration in the rumen. J. Anim. Sci. 58: 714-724.

Umunna, N.N. (1982): Utilization of poor quality roughage: response of sheep fed hay suplemented with urea by different methods. J. Agric. Sci. (Camb.) 98: 343-346.

Umunna, N.N. and Dankintafo, A. (1978): Optimum crude protein requirement of growing Zebu and Friesian X Zebu crossbred cattle in Nigeria. Proc. IVth World Conf. on animal prod. Buenos Aires, Argentina, pp 176-182.

Varga, G.A.; Hoover, W.H.; Junkins, L.L. and Shriver, B. (1982): Effects of urea and isoacids on in vitro fermentation of diets containing formaldehyde treated soybean meal. J. Dairy Sci. 65: (Suppl. 1) 125 (Abstr.).

Willams, C.L.; Berger, L.L.; Merchen, N.R. and Fahey, G.C. (1991): Effects of supplemented protein source and level of urea on intestinal amino acid supply and feedlot performance of lambs fed diets based on alkaline hydrogen peroxide-treated wheat straw. J. Anim. Sci. 69: 4925-4938.

Windschitl, P.M. and Stern, M.D. (1988): Effects of urea supplementation of diets containing lignosulfonate-treated soybean meal on bacterial fermentation in continuous culture of ruminal contents. J. Anim. Sci. 66: 2948-2958.

Tabl 1. Diet composition, chemical analysis on dry matter basis and feeding values of experimental rations.

Items	Rationsa			
	A	B	C	D
NTFMb	70.0	69.0	68.5	68.0
Corn	10.0	10.0	10.0	10.0
Wheat Straw	20.0	20.0	20.0	20.0
Urea	0.0	1.0	1.5	2.0
Chemical Analysis				
Dry matter (DM)	89.0	90.0	91.0	89.5
Crude Protein	10.3	12.7	13.6	15.0
Ether Extract	3.5	3.6	3.5	3.4
Crude Fiber	18.8	18.6	18.8	18.7
Ash	9.3	9.2	9.3	9.1
Nitrogen Free Extract	58.1	55.9	54.8	53.8
Feeding Value				
TDN	60.5	58.0	60.8	61.5
DCP	6.1	8.6	9.3	10.8
Urea N	0.0	22.0	30.9	37.3

a: Ration A= control; B= 1% urea; C= 1.5% urea and D= 2% urea.
b: NTFM= Non Traditional feed mixture cotains, corn, undecortecated cotton seed meal, wheat and rice brane.

Table 2. Effect of urea additiuon to the low protein ration on digestion coefficient.

Items	Rationsa			
	A	B	C	D
DM Digestibility	62.4	60.4	60.9	60.9
OM Digestibility	63.7	61.5	63.5	64.7
CP Digestibility	59.4	67.9	68.4	71.8
EE Digestibility	68.2	63.7	65.2	66.6
CF Digestibility	38.5	46.2	50.9	53.1
NFE Digestibility	71.9	63.8	67.1	66.4

a: Ration A= control; B= 1% urea; C= 1.5% urea and D= 2% urea.

Table 3. Nitrogen metabolism as affected by urea addition to the low protein rations.

Items	Rationsa			
	A	B	C	D
N intake g/day	16.48	20.32	21.76	24.00
N output g/day				
Fecal N	6.69	6.52	6.88	6.77
Urinary N	6.40	9.61	8.80	9.00
Total output	13.09	16.13	15.68	15.77
Output as a % of intake				
Fecal	40.59	32.09	31.60	28.20
Urenary	38.38	47.29	40.44	37.50
N retention				
g/day	3.39	4.19	6.08	8.23
% of intake	20.57	20.62	27.90	34.29

a: Ration A= control; B= 1% urea; C= 1.5% urea and D= 2% urea.

Table 4. Effect of feeding urea containing ration to sheep on body weight change, feed efficiency and daily water intake.

Items	Rationsa			
	A	B	C	D
Initial BW Kg	30.7 +4.94	28.5 +1.80	29.8 +2.86	29.8 +0.54
Final BW Kg	44.3 +5.02	44.8 +2.22	45.0 +3.33	49.5 +0.85
BW Change Kg	13.6 +3.00	16.3 +2.89	15.2 +1.48	19.7 +0.32
Daily Gain g	90.7f	108.7e	100.7e	132.0d
Feed intake /Kg gain	8.8d	7.4e	7.9e	6.1f
Water Intakeb				
Liter/day	3.048	3.173	3.078	3.189
Liter/Kg of BWc	0.0950	0.0998	0.1006	0.1111
Liter/Kg.75	0.2260	0.2369	0.2366	0.2572

a: Ration A= control; B= 1% urea; C= 1.5% urea and D= 2% urea.
b: Calculated for 30 days at the second month after the adaptation period.
c: Body weight used in the calculation is the animal BW at the 15th day of water intake measurement.
def Row means that do not have common superecripts differ (P<.05).

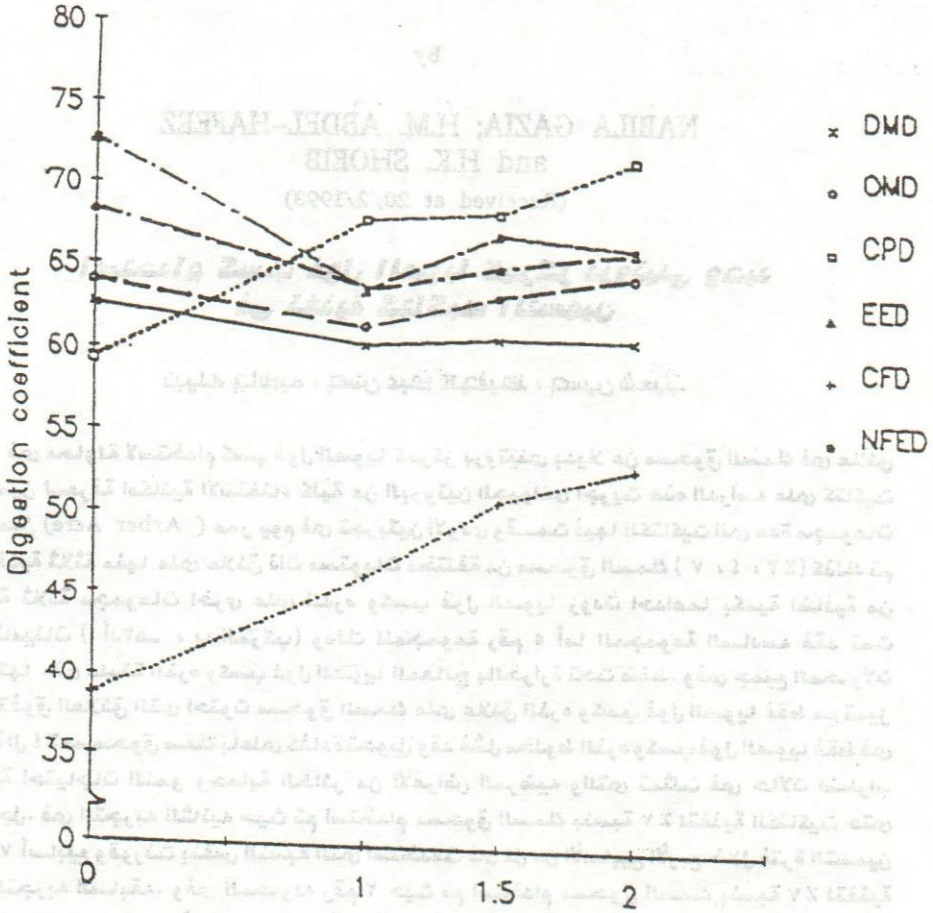

Figure 1. Effect of addition of urea to basal diet on digestion coefficient.