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Determining Effect of Lime and Urea Treatment on Crude and Digestible Nutrient Content of Wheat Straw

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Abstract: This study was conducted to determine the effects of lime and urea treatment on crude and digestible nutrient content of wheat straw. Experimental diets consisted of 80 percent straw treated with combination of 2 or 4 % urea and 2.5 or 5% lime or untreated straw and 20% ground wheat grain. An apparent digestion trial was conducted according to 5 x 5 Latin square design using 5 Awassi ram lambs, 5 diets, and 5 periods. Diets containing treated straw had lower organic matter ($P < 0.01$), higher crude protein content ($P < 0.05$) than diets with untreated straw . All the diets had the similar crude fat and fiber content ($P > 0.05$). Urea and lime treated straw containing diets had better organic matter, crude fiber, and crude protein digestibility than untreated straw containing diets ($P < 0.05$) . Treating wheat straw with lime and urea also improved dry matter intake and organic matter intakes and decreased diet consumption and ruminating lenght ($P < 0.05$).

Key words: Straw, Lime, Urea, Digestibility

Introduction

Wheat straw is the most abundant feed resource for ruminant animals in Turkey especially during the winter season and its lower utilization by the ruminants due to high levels of cell wall lignification and lower rumen degradation is the one of the main limiting factors causing lower productivity of the ruminant animals. Physical, chemical and biological treatments have been examined to improve utilization of straw and other low quality forages for ruminants but no physical, chemical and biological practical method have been successfully designed. Chemical treatments include the use of alkaline, acidic or oxidative agents. According to current state of knowledge, alkaline agents can chemically break the ester bonds among lignin hemicellulose and cellulose, and physically make structural fibers swollen (Schiere and Ibrahim, 1989; Chenost and Kayouli, 1997). These cause rumen microorganisms to attack the structural carbohydrates more easily, increasing digestibility and palatability of the treated straw (Bod'a, 1990). Treatment of straw with sodium hydroxide (NaOH) and ammonia (NH_3) to improve its digestibility and intake has been extensively examined (Jackson, 1977; SundstØl and Owen, 1984). However, both chemicals have potential hazards for animals, humans and the environment in addition to economical and technological limitations (Owen *et al.*, 1984). Usage of urea treatment is a much more safer than anhydrous or aqueous ammonia (Berger *et al.*, 1994). Moreover, it considerably cheaper than NaOH or ammonia, and can be supplied much more easily from local markets. However, the use of urea alone is an expensive way of supplying nitrogen to ruminants, as the level required for effective treatment of straw is 50% greater than what is required by the rumen microorganism (Preston, 1995). Lime is also potential alkali for straw treatment since it is cheaper and readily available (Owen *et al.*, 1984). Calcium residues, which remain in the treated straw, cause no serious problems to the animal or to the environments (Chaudhry, 1998b).

Combination of lime and urea would be able to combine treatment effects of both chemicals (Sirohi and Rai, 1996; Sirohi and Rai, 1999), together with the supplemental effects of the added Ca and nitrogen in the treated straw. Moreover, additional effect may be achieved as lime enhance the decomposition of urea into ammonium hydroxide (Van Soest *et al.*, 1994).

The objective of this study was to determine the effects of urea and lime combination treatment on wheat straw based diet nutrient content, their digestibility, intake and ewe rams eating and ruminating behavior.

Materials and Methods

Five ram lambs of a Awassi breed at 10-12 months of age with average weigh of 34.7 ± 1.5 for apparent digestion trial were used. Wheat straw, mineral blocks and ground wheat grain were supplied from the Harran University Animal Science Department Sheep Research Unite. Sun-dried wheat straw in the chopped form was sprayed with the respective solution of lime and urea combination, which was dissolved in required amounts of water to keep the straw moisture level at 60%. The treated straw was then mixed by thoroughly on concrete floor with shovel. Then the mixed straws were placed in plastic barrels of approximately 20 kg each and covered with plastic sheet. Thereafter sand bags were used as a weight after being carefully pressed to remove air. Barrels were stored in a shed for 2 weeks and then treated straw was dried on the plastic sheet under the Sun for 3-4 days. Sun dried treated straws were stored in the labeled plastic bags until the apparent digestion trial. Experimental diets

consisted of 80 percent straw treated with combination of 2 or 4 % urea and 2.5 or 5% lime or untreated and 20% ground wheat grain. The apparent nutrient digestibility of diets was determined according to 5 x 5 Latin square design using 5 Awassi ram lambs, 5 diets and 5 periods. Each period experimental animals were fed test diets ad libitum twice a day at 8 am. and 8 pm. for a preliminary period of 10 days to ensure that residues of previous diet have been eliminated from the digestion tract. Eighty percent of the preliminary intake levels of diets was fed following 5 d transition period and 7 d in length collection periods (13). Collection of feces was accomplished by housing the animals in creates and animals were fitted with specialized harnesses and bags which facilitate collection of feces. During the faeces collection periods 50g of diets were taken ever day from the through at feeding to make composite samples for whole period. Feaces was collected immediately after excretion and bulked daily for total weight determination and then a 10% representative sample was taken to make running composite samples for individual animals. All the diet and faecal samples were preserved in sealed polyethylene bags stored in freezers until chemical analyses. Drinking water and mineral block was supplied in free access at all times. At the beginning and the end of the trials the animals were weighed for two consecutive days before morning feed using digital scale.

Fecal samples were dried in an oven at 65 °C for 48 h. Fecal and diet samples were ground to pass 1mm screen for chemical analysis. Dry matter (DM), organic matter (OM), crude fat (CF), nitrogen-free extract (NFE) contents of diets and feces was analyzed using Weende Analysis Method described by Akyildiz (1984). Crude protein (CP) was determined following Official Methods of AOAC (1990). Crude fibers (CF) were determined according to Crampton and Maynard (1938).

Each of the experimental animals was observed continuously for two consecutive days during feces collection periods to record eating and ruminating times. Three persons took turns to record the eating and ruminating times of five animals using clocks and spreadsheets. Feed intake on those particular was also determined to calculate eating (minute/ kg diet DM) and ruminating length (minute/ kg diet DM).

Data were analyzed using the General Linear Model (GLM) procedure of the SAS (1989) and mean separated was done by Least Significant Differences (LSD). Significance was declared at the $P < 0.01$ or $P < 0.05$.

Results

Chemical composition of the diets consist of 80 % straw treated or untreated and 20% ground wheat grain are given in Table 1. All the treated straw containing diets except 4% urea and 2.5% lime treated one had a lower OM than did the untreated straw containing diet ($P < 0.05$). Treated straw with urea lime increased CP content of the diet ($P < 0.01$) but did not affect EE and CF content of diets ($P > 0.05$). Nitrogen-free extract of diets also diminished with urea and lime treatment. Nutrient digestibility of the diets is presented in Table 2. Urea and lime treatment increased OM digestibility (except 2%urea and 2.5% lime), CP digestibility (except 2% urea containing diets), and crude fiber digestibility ($P < 0.05$), but did not affect NFE digestibility of diets ($P > 0.05$). Dry matter intake (DMI), digestible organic matter intake (DOMI), DM consumption length (DMCL), ruminating length (RL) of diets and average daily gain (ADG) of ram lambs were shown in Table 3. Treating straw with urea and lime

Table 1: Chemical composition of the diets consists of straw 80% treated or untreated w and 20% ground wheat grain

Diets	Chemical Composition (% of DM)				
	Org. Matter (OM)	Crude Protein (CP)	Ether Extract (EE)	Crude Fiber (CF)	N-Free Extract (NFE)
Untreated	92.76^{a}	6.36^{c}	1.51^{a}	33.40^{a}	51.50^{a}
2% urea-2.5% lime	91.56^{b}	7.33^{b}	1.33^{a}	34.03^{a}	48.88^{b}
2% urea-5% lime	90.33^{c}	7.11^{b}	1.10^{a}	33.20^{a}	48.92^{b}
4% urea-2.5% lime	92.06^{ab}	8.68^{a}	1.44^{a}	33.71^{a}	48.20^{b}
4% urea-5% lime	90.68^{c}	9.03^{a}	1.07^{a}	34.49^{a}	46.09^{c}
Standard Error of Mean (SEM)	0.25*	0.17**	0.17*	0.50*	0.67*

^{abc}Mean within same column with similar superscirpt are not different *: $p<0.05$; **: $P<0.01$

combination increased DMI and DOMI ($P < 0.01$) and also decreased DMCL of RL of diets ($P < 0.05$). All the treated straw containing diets(except 4% urea and 2.5% lime) gained weight.

Discussion

All TS containing diets had higher CP content than UTS containing diet ($P < 0.01$) and increment of urea in treatment from 2% to 4% also increased CP content of diet ($P < 0.01$). This is in agreement with results reported earlier (Sadullah *et al.*, 1981; SunstØl and Coxworth 1984; Trach *et al.*, 1998). However, the CP content in this study was increased 1 percentage units on DM basis at the expense of 2% urea, only 17% of the additional urea

Table 2: Nutrient digestibility of the diets consist of 80% straw treated or untreated and 20% ground wheat grain

Diets	Degestibility %				
	Org. Matter (OM)	Crude Protein (CP)	Ether Extract (EE)	Crude Fiber (CF)	N-Free Extract (NFE)
Untreated	52.87^{b}	46.82^{b}	60.53^{a}	52.63^{b}	52.86^{a}
2% urea -2.5% lime	54.79^{ab}	46.01^{b}	40.09^{bc}	57.28^{a}	54.71^{a}
2% urea -5% lime	55.77^{a}	51.39^{ab}	32.81^{c}	58.21^{a}	55.04^{a}
4% urea -2.5% lime	55.07^{a}	60.12^{a}	55.08^{ab}	57.43^{a}	52.36^{a}
4% urea -5% lime	55.09^{a}	57.75^{a}	35.53^{c}	59.19^{a}	52.16^{a}
Standard error of Mean (SEM)	0.67*	2.02**	5.48*	1.10**	1.15*

^{abc}Means within same column with similar superscript are not different *:p<0.05 **: P<0.01

Table 3: Dry matter intake (DMI), digestible organic matter intake (DOMI), DM consumption length (DMCL), ruminating length (RL) of diets and average daily gain (ADG) of ram lambs

Diets	DMI g/day	DOMI g/day	DMCL Min./ 1kg diet DM	GGS Min./ 1kg diet DM	ADG g/day
Untreated	508^{b}	249^{a}	319^{a}	1163^{a}	-200^{b}
2% urea-2.5% lime	620^{a}	311^{b}	256^{b}	913b^{c}	30^{a}
2% urea-5% lime	632^{a}	319^{b}	241^{b}	879^{bc}	6^{ab}
4% urea-2.5% lime	591^{a}	301^{b}	260^{b}	100^{9b}	-75^{ab}
4% urea-5% lime	616^{a}	308^{b}	219^{b}	847^{c}	17^{a}
Standard Error of Mean (SEM)	18.16**	11.35**	18.44*	45.01*	68.91*

^{abc}Means within same column with similar superscript are not different *:p<0.05 **: P<0.01

nitrogen increment was fixed. The nitrogen remain in straw was chemically fixed to the cells of the straw and thus insoluble in water. Chenost and Kayouli (1997) stated that the N fixation ratio usually falls with the increase in the urea level because large amounts of free ammonia built up within the straw matter may stop or hinder hydrolysis of urea. In contrast, increasing urea level increased fixed N content as same ratio in this study.

Urea and lime TS containing diets had the similar CF and EE content (P >0.05). This is in agreement with a previous conclusion that lime and urea treatment did not affect cell components (NDF, ADF, ADL) of straw (Trach *et al.*, 1998). In contrast, Giang and Trach (2001) reported that urea and lime treatments tended to reduce the NDF content. The various fiber and lignin content may provide little information on the nutritive value of TS (SuntØl *et al.*, 1978) unless the treatment eventually improve digestibility of straw.

Urea and lime treatment of straw increased OM digestibility (except 2%urea and 2.5% lime) (P>0.05). Giang and Trach (2001) indicated that 2% urea and 4% lime treated rice straw had a 61.5 % of apparent OM digestibility while untreated rice straw had a 47.2% OM digestibility. Zaman and Owen (1995) concluded that mixtures of lime and urea would be alternative chemicals to NaOH or ammonia for improvement of the nutritive value of straw. After comparison of different urea and lime combination, Sirohi and Rai (1995) indicated that a combination of 3% urea plus 4% lime at 50% moisture for 3 weeks reaction time was the most effective treatment for improving digestibility of straw. In current study, increment of OM digestibility was less than mentioned in those studies. This can be explained with shorter reaction time (15d vs 21d) and 20% wheat grain addition to straw diet. Ether extract digestibility was found lower in 5% lime containing diets (P <0.05). Calcium content of lime probably caused calcium soap formation in the digestion tract, therefore EE digestibility was reduced.

Urea and lime treatment improved CF digestibility of diets (P <0.05). This result can be explained by the fact that urea and lime might chemically break the ester bonds between the structural carbohydrates and lignin, therefore rumen microorganisms can attack the structural carbohydrates and digest them easily (Chenost and Kayouli, 1997; Bod'a, 1990).

Possibly, due to increased of DM digestibility, TS containing diets had higher DMI and DOMI than that of untreated straw containing diet (P <0.01). These results are in agreement with results reported earlier (Zaman and Owen 1990; Zaman and Owen 1995; Pradhan *et al.*, 1997).

Urea and lime treatment decreased DMCL of RL of diets (P <0.05) and also resulted in weight loss of the ram lambs (P <0.05). Similar results have also been reported by Trach *et al.*, (1998).

Urea and lime treatment increased CP content, digestibility of CP, CF, and OM and DMI and SOMI of wheat straw containing diets. It is therefore concluded that good results can be obtained from the straw treatment with urea and lime in combination.

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References

Akyildiz, A. Yemler Bilgisi Laboratuar Kilavuzu. Ank. Üniv. Zir. Fak. Yay. No: 895. 1984 Ankara.

AOAC. 1990. Official methods of analysis. Association of Official Analytical Chemists. 15th ed. Association of Official Analytical Chemists. Arlington, VA, USA. pp: 69-88. 1990.

Berger, L. L., G. C. Fahey, J. R. L. D. Borquin and E. C. Tilgeyer, 1994. Modification of forage quality after harvest. In Fahey Jr. G.C. (ed.) Forage Quality, Evaluation, and Utilization. Madison. Wisconsin. USA.

Bod'a, K. 1990. Non conventional Feedstuffs in the nutrition of farm Animals. Developments in Animal and Veterinary 23. Elsevier. Amsterdam-Oxford-NewYork-Tokyo.

Chaudhry, A. S.1998b. In- vitro and in-sacco digestibility of wheat straw treated calcium oxide and sodium hydroxide alone or hydrogen peroxide. Animal feed Science and Technology., 74: 301-313.

Chenost, M. and C. Kayouli, 1997. Roughage utilization in warm climates. FAO animal production and health paper 135. Rome.

Cochran, R. C. and M. I. Galyean, 1994. Measurement of in-vivo forage digestion by ruminants. In G.F. Fahey, Jr. (ed.) Forage Quality, Evaluation, and Utilization, Madison, USA. pp, 613-643.

Crampton, E. W., L. A. Maynard, 1938. The relation of Cellulose and Lignin Content to Nutritive Value of Animal Feeds. J. Nutr., 15: 383-395.

Giang, V. D. and N. X. Trach, 2001. Effects of treatments with and/or urea on rice straw chemical composition, intake and degradability. Proceeding-Workshop on improved utilization of by-products for animal feeding in Vietnam. Proceeding –workshop on improved utilization of by-products for animal feeding in Vietnam-NUFU project-3. 14 pp: 28-30 March.

Jackson, M. G., 1977. The alkali treatment of straws. Animal Feed Science and Technology., 2:105-130.

Owen, E., T. Klopfenstein, N. A. Urino, 1984. Treatment with other chemicals. In SundstØl F. and Owen, N.C.(Eds.). Straw and Other By-products as Feed. Elsevier. Amsterdam. pp: 248-275.

Pradhan, R., H. Tobioka and I. Tasaki, 1997. Effect of moisture content and different levels of additives on chemical composition and in vitro dry matter digestibility of rice straw. Animal Science and Technology (Japan)., 3: 273-284.

Preston, T. A., 1995. Tropical Animal Feeding- A manual for research worker. FAO animal production and health paper 126. Rome.

Saadullah, M., M. Haque, F. Dolberg, 1989. Treatment of rice straw with lime. Trop. Anim. Prod. 1981; 6: 30-36.

Schiere, J. B. and M. N. M. Ibrahim, 1989. Feeding of Urea Ammonia Treated Rice Straw. Pudoc. Wageningen.

Sirohi, S. K. and S. N. Rai, 1995. Associative effect of lime plus urea treatment of paddy straw on chemical composition and in vitro digestibility. Indian J. Anim. Sci., 65: 1346-1351.

Sirohi, S. K. and S. N. Rai, 1996. Synergic effects of lime plus urea treated paddy straw on in-sacco digestibility and in vitro gas production rate. Indian Journal of Animal Nutrition., 13: 214-219.

Sirohi, S. K. and S. N. Rai, 1999. Synergitic effect of lime and urea treatment of wheat straw on chemical composition, in-sacco and in-vitro digestibility. Asian-Australian J. Animal Sci., 12: 1049-1053.

SunstØl, F. and E. M. Coxworth, 1984. Ammonia treatment. In. Sundstol, F. and Owen, E. C Straw and other by-products as feed. Elsevier, Amsterdam. pp: 196-240

SunstØl, F., V. Kosila, O. Theander and K. V. Thomsen, 1978. Evaluation of feeding value of straw- A comparison of laboratory methods in the Nordic countries. Acta Agri. Scand., 28:10-16.

SundstØl, F. and E. C. Owen, Straw and Other By-products as Feed. Elsevier, Amsterdam. 604 pp: 1984.

Trach, X. N., C. X. Dan., L. V. Ly And F. SunstØl, 1998. Effect of urea concentration, moisture content, and duration of treatment on chemical composition of alkali treated rice straw. Livestock Research for Rural Development., 10: 1-6.

Van Soest, P. J., 1994. Nutritional Ecology of the Ruminant, 2nd ed. Cornell University Press. USA. pp: 476.

Zaman, M. S. and F. Owen, 1990. Effect of calcium hydroxide or urea treatment of barley straw on intake and digestibility in sheep. Small Ruminant Res., 3: 237-248.

Zaman, M. S. and F. Owen, 1995. Effects of calcium hydroxide or urea treatment of barley straw on chemical composition and digestibility *in vitro*. Animal Feed Science and Technology., 51:165-171.