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Effect of Urea Treatment on Chemical Composition and In-Vitro Organic Matter Disappearance of Some Poor Quality Roughages

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THE EFFECT of urea (3% and 5% on DM basis) on the quality of five roughages were studied; rice straw, wheat straw, corn cobs, cotton stalks and bagasse. Samples of 100 g each were sprayed with 3% or 5% (w/w) urea solution, and stored in sealed polyethelene bags for 2, 4, 6 and 8 weeks at room temperature. Total-N, non-NH3-N, fiber constituents and IVOMD of urea treated samples were significantly ($P < 0.01$) affected by type of roughage. Crude fiber, total-N and NH3-N were increased ($P < 0.01$) as urea level increased. Treatment period length did not significantly influence either OM, CF, total-N,NH3-N, hemicellulose, ADL, gross energy or IVOMD of the treated roughages. High negative correlation was calculated between NFE and total-N ($r = -0.85$), CF ($r = -0.67$), hemicellulose ($r = -0.61$) and ADL ($r = -0.77$). However, total-N was positively correlated with CF ($r = 0.65$), Hemicellulose ($r = 0.65$) and ADL ($r = 0.67$).

Key words : Roughage, urea, chemical composition.

Straws, stalks and stovers constituents a vast under-utilized source of carbohydrates. It has long been known (Beckmann, 1921 and Homb, 1948) that treatment of crop residues with alkali results in an increase in their digestibility by ruminants. Use of urea treatment had been recommended (El-Shinnawy and Abou-Raya, 1983 and Mason and Owen, 1985) to improve the nutritive value of poor quality roughages. Urea is a fast hydrolysied substance providing ammoniation condition which may enhance the degradation of lignocellulosic biomass (Solaiman *et al.*, 1979 and Van Soest, 1982). Urea treatment has advantages over other alkali treatments that;

(1) easy and cheap process,

(2) undesirable excess chemicals evaporate with free access to air,

(3) ammonia bound to the roughage during the reaction, can serve as a source of nitrogen.

However, some recent evidences indicated that urea treatment can inhibits the growth of lactic acid bacteria (Deschard, 1983; Mason, 1986), and also there is a possibility for imidazols and ammonium carbonate formation which are toxic substances (Almeida *et al.*, 1989).

The objective of the present study was to determine changes in chemical composition (fiber constituents and free ammonia) gross energy and in-vitro organic matter disappearance (IVOMD) for different types of roughages treated with two levels of urea solution and stored for different periods.

Material and Methods

Representative samples of rice straw, wheat straw, corn cobs, cotton stalks and bagasse were ground thru a 0.5 cm hammermill screen. Nine equal portions each of 100 g were weighed from each roughage and packed in polyethylene bags. One portion was used as a control sample (0% urea), while four samples were sprayed with 3% urea solution and the other four samples were sprayed with 5% urea solution. Urea solutions were prepared by dissolving 3 or 5 g of urea (46% nitrogen) in 100 ml water. Bags of different roughage samples were sealed under vacuum and stored at room temperature (18-25°C) for 2,4,6 and 8 weeks. Chemical composition of non-aerated samples including dry matter (DM), total nitrogen (Total-N), ether extract (EE), crude fiber (CF) and ash was determined according to A.O.A.C. (1980). Fiber fractions, neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Goering and Van Soest (1970). Ammonia-nitrogen (NH3-N) was immediately determined by the end of each storage period for all samples using over saturated solution of potassium carbonaote (5 ml solution per g fresh sample) and through the aeration method described by Abou-Akkada and Naga (1970), NH3-N was trapped after 20 min in 2% boric acid solution. Gross energy was determined by an adiabatic bomb calorimeter. Two stage in-vitro technique was applied to evaluate IVOMD (Tilley and Terry, 1963). Statistical analysis was performed using the general linear model procedure (SAS, 1982). Least significant difference (LSD) between means was calculated according to Snedecor and Cochran

(1980). Simple correlation was calculated between the different measurable nutrients. Correlation coefficients (r) less than 0.6 were discarded.

Results and Discussion

Chemical composition and fiber constituent percentages of untreated roughages are presented in Tables (1 and 2). Rice straw and wheat straw showed higher ash content than other tested roughages, while cotton stalks and bagasse showed the highest values of ADL. Cell contents (100-NDF) averaged 30% (DM basis) for rice straw, wheat straw and cotton stalks, while an average of 15% was recorded for cell contents in corn cobs and bagasse.

TABLE 1. Chemical composition of untreated experimental roughages.

Roughage	DM	DM composition, %				
	%	CP*	EE	CF	NFE**	Ash
Rice straw	95.6	3.5	1.0	37.6	39.4	18.5
Wheat straw	95.7	5.1	1.2	40.4	37.2	16.1
Corn cobs	94.3	3.0	0.6	34.3	60.3	1.8
Cotton stalks	94.0	3.8	0.6	47.5	44.1	4.0
Bagasse	93.7	1.4	0.6	44.3	50.3	3.4

* Crude protein (N × 6.25).
** Nitrogen free extract calculated by difference.

TABLE 2. Fiber constituents of untreated experimental roughages.

Roughage	Dry matter, %				
	NDF	ADF	ADL	Hemicellulose	Cellulose
Rice straw	66.4	55.1	5.9	11.3	49.2
Wheat straw	71.2	55.9	8.2	15.3	47.7
Corn cobs	86.4	47.8	9.5	38.6	38.3
Cotton stalks	67.9	55.5	13.9	12.4	41.6
Bagasse	85.3	63.1	10.0	22.2	53.1

Hemicellulose = NDF — ADF
Cellulose = ADF — ADL

From urea treated samples, a strong ammonia smell arose when the bags were opened. No mould deterioration was observed in any of the tested samples.

Data concerning the responses of different roughages to urea treatment on nitrogen content, fiber constituents and IVOMD are presented in Table (3). Roughages differed ($P < 0.01$) in all measured parameters. The highest nitrogen content was recorded for cotton stalks. Total-N reached 2.69% (DM basis) in cotton stalks and non-NH3-N achieved 65.4% of total-N. The corresponding values were 58.6, 56.7, 49.1 and 43.8% for rice straw, corn cobs, wheat straw and bagasse, respectively. Rice straw and wheat straw contained lower ADL fraction being 5.8% and 8.5%, respectively. The IVOMD showed variable values between different treated roughages that

TABLE 3. Nitrogen content, fiber constituents and IVOMD of the experimental roughages treated with 3% or 5% urea solution. (DM)

Chemical composition & IVOMD	Experimental roughages					SED
	Rice straw	Wheat straw	Corn cobs	Cotton stalks	Bagasse	
Moisture, %	48.8	48.8	53.9	54.3	55.2	
Nitrogen, %						
Total-N	AB 2.35	Bb 1.92	ABa 2.39	A 2.69	B 2.05	0.21
Non-NH3-N	AB 1.42	B 0.96	AB 1.38	A 1.75	B 0.98	0.25
Non-NH_3-N, % of total-N	58.6	49.1	56.7	65.4	43.8	9.4
Fiber constituents, %						
Hemicellulose	D 15.9	CDb 18.9	A 40.5	BCa 24.4	B 24.8	2.1
Cellulose	B 45.2	B 45.0	C 35.0	B 42.3	A 53.6	2.4
ADL	E 5.8	D 8.5	B 15.7	A 19.8	C 12.4	0.6
IVOMD, %	A 35.3	Ba 24.8	C 14.3	Bb 20.0	C 12.3	1.8

Non-NH_3-N = Total-N — NH_3-N.

SED = Standard error of difference.

a,b Means with different superscripts in the same row are ($P < 0.05$) different.

A,B,C,D,E Means with different superscripts in the same row are ($P < 0.01$) different.

means response to urea treatment might be limited by the physical and chemical structure of roughage material. Van Soest (1982) and Michael (1985) reported that physical and chemical association between lignin and the cell wall polysaccharides, the degree of crystallinity within the cellulose polymer itself, ash and cell wall high contents, all are obstructs of OM digestibility. Data in Table (4) showed that as the level of urea treatment increased (only from 3 to 5% urea) roughage contents of crude fiber, total-N and NH_3-N

TABLE 4. **Effect of urea level on changes of nutrient contents, fiber constituents, gross energy and IVOMD of the experimental treated roughages (DM).**

Chemical Composition % IVOMD	Level of urea treatment 0%	3%	5%	SED
Moisture, %	5.3	51.7	52.7	
Nutrient, %				
OM	91.2	91.0	91.0	2.3
CF	Bb 40.8	Bb 41.8	Aa 46.4	1.9
NFE	A 46.3	B 35.4	C 28.4	2.4
Fiber constituents, %				
Hemicellulose	20.0	25.6	24.2	3.1
Cellulose	46.0	44.2	44.3	2.2
ADL	9.5	12.5	12.4	1.4
Nitrogen, %				
Total-N	C 0.54	B 2.08	A 2.48	0.12
NH3-N	C 0.00	B 0.73	A 1.24	0.06
NH_3-N % of Total-N	C 0.00	B 37.9	A 53.1	4.9
Gross energy, Kcal/g	3.956	3.910	3.923	0.100
IVOMD, %	24.1	21.8	20.9	2.9

SED = Standard error of difference.

a,b Means with different supercripts in the same row are ($P < 0.05$) different.

A,B,C Means with different superscripts in the same row are ($P < 0.01$) different.

were found to be ($P<0.01$) increased. In this connection, Jayasuriya and Perera (1982) mentioned that about 25% of urea applied at the time of treatment would have escaped to the atmosphere as free-NH3 during the exposure of the ensiled material for 2 hr before feeding to the animals. Hadjipanayiotou (1982) found that free NH_3-N accounted for 31% of the total-N and about 44% of the added N was retained in urea treated barley straw. Comparable values to the present results of NH_3-N ranged 43.4% - 57.5% were reported by Solaiman *et al.* (1979) and Dias-da-Silva and Sundstol (1986). Urea treatment increased the roughage content of ADL by 30% (from 9.5% to 12.5%). However, this increase was not statistically proven. McBurney (1985) mentioned that urea treatment may have catalyzed the synthesis of lignin-like materials. Nitrogen-free extract declined from 46.3% to 28.4% by using 5% urea solution. However this change was not associated with changes of organic matter or gross energy content. Such observation probably associated with increasing urea level. This might refer to the use of factor 6.25 to convert total nitrogen into crude protein seems not applicable in case of nitrogen of urea or other NPN compounds. Meanwhile, one gram of urea theoretically provides 2.88 g crude protein, which is not actually true to be deducted from the OM content. The insignificant decrease in IVOMD associated with the increase of urea treatment level might be due to the possibility of the presence of some toxic compounds (4-methylimidazol or carbonate) formed by urea reaction with reduced sugars or carbon dioxide during the anaerobic storage conditions (Almeida *et al.*, 1989). Negative correlation coefficients between NFE and total-N ($r = -0.85$), CF ($r = -0.67$), hemicellulose ($r = -0.61$) and ADL ($r = -0.77$) were calculated. However, positive correlations were detected between total-N and CF ($r = 0.65$), hemicellulose ($r = 0.65$) and ADL ($r = 0.67$).

Effect of treatment-period length on chemical composition, gross energy and IVOMD is presented in Table (5). No significant influence has been observed due to treatment time on OM, CF and NFE. Total-N and NH3-N were affected by the storage period length. Total-N did not significantly changed from the 4th to the 8th week post-treatment. The unexpected low total-N content at the 2nd week might be related to the high NH3-N content (68.8% of total-N) which is easy to be escaped by sample exposure to atmosphere during nitrogen determination. Ammonia-N % of total-N averaged 37.7%

TABLE 5. Effect of treatment-period length on changes in nutrient contents, fiber constituents, gross energy and IVOMD of urea treated roughages (DM).

Chemical Composition & IVOMD	Length of Treatment period (week)				SED
	2	4	6	8	
Moisture, %	54.0	51.1	51.1	52.6	
Nutrient, %					
OM	90.8	91.2	91.2	90.9	3.3
CF	44.0	44.3	43.8	44.2	3.2
NFE	34.0	32.1	31.8	29.8	3.6
Fiber constituents, %					
Hemicellulose	26.9	20.0	24.6	28.1	4.2
Cellulose	41.2 Bb	50.9 Aa	43.6 b	41.1 Bb	3.0
ADL	12.2	12.3	12.7	12.5	2.4
Nitrogen, %					
Total-N	1.93 Bb	2.24 ab	2.38 a	2.58 Aa	0.20
NH3-N	1.26 Aa	0.77 Bb	0.96 b	0.96 b	0.13
NH3-N, % of					
Total-N	68.8 A	35.0 B	41.1 B	37.0 B	7.0
Gross energy, Kcal/g	3.910	3.921	3.900	3.936	0.160
IVOMD, %	19.4	23.0	20.8	22.2	4.1

SED = Standard error of difference.

a,b Means with different superscripts in the same row are ($P < 0.05$) different.

A,B Means with different superscripts in the same row are ($P < 0.01$) different.

throughout the period from 4th to 8th week of storage. Similar results were reported by Solaiman *et al.* (1979) while, higher values of NH3-N as a percentage of total-N being 52.5% - 57.5% were recorded for wheat straw treated with 8% urea after 60 days of storage (Dias-da-Silva and Sundstol, 1986).

From 2nd to 4th week, cellulose ($P < 0.01$) increased from 41.2% to 50.9% and IVOMD insignificantly increased from 19.4% to 23.0%, while hemicellulose insignificantly decreased from 26.9% to 20.0%. No obvious changes in the measured parameters had been observed during the period from 4th to 8th week. It is a big

deal from the present results concerning chemical composition and IVOMD of urea treated roughages that there were no marked changes could be achieved after 4 week post-treatment. Almost similar conclusion was suggested by Jayasuriya and Perera (1982) and Hadjipanayiotou (1982). In contrary, effective storage period from one to 10 days was suggested (Waiss *et al.*, 1972; Waagepetersen and Thomsen, 1977 and Solaiman *et al.*, 1979). Organic matter, CF, NFE and gross energy were not affected by length of the storage period.

It could be concluded that urea treatment may improve the nitrogen content of poor quality roughages mean while, in vitro organic matter digestibility is not always entirely affected. The polysaccharide structure and its linkages within the cell wall matrix are the limiting factors controlling the response of different roughages to urea treatment.

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تأثير المعاملة باليوريا على التركيب الكيمائى وهضم المادة العضوية (معمليا) لبعض مواد العلف الخشنة الفقيرة

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تم معاملة عينات مطحونة (٥ر٠ سم) من كل من قش الارز ، تبن القمح ، قوالح الذرة ، حطب القطن ومصاصة القصب بمحلولين من اليوريا تركيزهما ٣ ٪ ، ٥ ٪ (وزن / وزن) . وزنت تسع عينات من كل مادة كل منها ١٠٠ جم ووضعت كل عينة داخل كيس من البولى ايثلين ثم رشت اربع عينات منها بمحلول اليوريا ٣ ٪ بينما رشت الاربعة الاخرى بمحلول اليوريا ٥ ٪ وتركت عينة بدون رش للمقارنة . حفظت جميع اكياس العينات بعد سحب الهواء منها واحكام اغلاقها على درجة حرارة الغرفة (١٨ ـ ٢٥ م°) لمدة ٢ ، ٤ ، ٦ ، ٨ أسابيع . اوضحت النتائج أن هناك اختلافا معنويا ($P < 0.01$) بين المواد المختلفة من حيث درجة تأثر تركيبها الكيماوى ومعامل هضم المادة العضوية المقدرة معمليا نتيجة المعاملة . وجد أنه بزيادة مستوى تركيز اليوريا فى المعاملة تتزايد معنويا ($P < 0.01$) نسبة الالياف الخام (فقط من ٣ الى ٥ ٪) الازوت الكلى والامونيا الحرة . بينما لم يلاحظ تغير معنوى بالنسبة للتركيب الكيماوى ومعامل هضم المادة العضوية بطول فترة التخزين من ٢ الى ٨ أسبوع . كان هناك ارتباط معنوى سالب بين كل من المستخلص الخالى من الازوت وكل من الازوت الكلى (ـ ٨٥ر٠) ، الالياف الخام (ـ ٦٧ر٠) ، الهيميسليولوز (ـ ٦١ر٠) ومستخلص اللجنين الحامضى (ـ ٧٧ر٠) ، بينما كان هناك ارتباط معنوى موجب بين كل من الازوت الكلى وكل من الالياف الخام (٦٥ر٠) ، الهيميسليولوز (٦٥ر٠) ومستخلص اللجنين الحامضى (٦٧ر٠) .