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On-station evaluation of straws and stovers with urea to increase utilization in Somali Region

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Wheat straw (WS), barley straw (BS), sorghum stover (SS), and maize stover (MS) were subjected to different times of ensiling and urea treatment levels in order to identify the most effective ensiling time and urea treatment level to attain preferable nutritional aptitude. Both straws and stovers were treated with 0.40 and 0.50 g concentration levels of urea solution dissolved in 0.8 L of water and sealed plastic sheet for one to four weeks. Accordingly, to the general observation at the time of opening, there was no mold growth, appeared golden brown in color, and had soft consistency with a strong ammonia smell ensuring the effectiveness of the treatment. The chemical analyses and IVDMD were done at HRCL. The results showed that the urea level had a no-significant effect on all chemical compositions and IVDMD for all urea-treated straws and stovers. Therefore, treatment with 40 g urea may be more economical. On the other hand, negative and significant ($P < 0.001$) correlations existed between IVDMD and fiber fractions for all treatments. While other quality parameters, IVDMD and CP, were strongly correlated ($r = 0.90$) ($P < 0.01$) for WS and BS. The results also revealed that the treatment duration on both straws and stovers should be 28 days.

Key words: Treatment, ensiling time, chemical analysis, digestibility, crop residues.

INTRODUCTION

Ethiopia has the largest cattle population in Africa with an estimated 56.71 million heads of animals. Out of this total cattle population, the female cattle constitute about 55.45% and the remaining 44.55% are male cattle (CSA, 2015). According to SRS BoFED, currently the region has also huge livestock population estimated to be 26.8 million of which cattle (20%), sheep (33%), goat (36%), camel (10%) and equines (1%), contributing considerably to the national economy and the livelihood of the people.

Regardless of their number, however, the productivity per head is usually low mainly because of inadequate year round nutrition, unimproved genetic resources and prevalence of diseases and parasites.

Under-nutrition, due to inadequate or fluctuating nutrient supply, is a major constraint limiting the productivity of the livestock, leading to high mortality of animals, longer parturition intervals and substantial weight loss, particularly during the dry season in most parts of the

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region. At this period most of the animals depend on matured herbage, aftermath grazing and crop residues, which are usually, low in protein, digestible energy and minerals (Seyoum and Zinash, 1998) which may result in lowered animal performance. Residues of cereals and pulses account for about 26% of the total feed utilized and ranked second to grazing (64%) in mixed crop-livestock production system of Ethiopia (CSA, 2004). It is also estimated that above 18.5 million metric tons of crop residues are annually produced in the country (Azage et al., 2002), out of which 70% is utilized for livestock feeding dominated by cereal straws.

Crop residues are generally characterized by low nutritive value, but have potential degradability as high as 80%, but are low in actual digestibility rarely exceeding 50% due to close association of carbohydrates with lignin (Jackson, 1977). However, poor quality roughages such as straws have the potential for improving animal feeding by employing different strategies.

Urea treatment has most practical significance in the tropics by acting both as an alkali and as a source of nitrogen to roughages inherently low in protein, resulting in a successful improvement in digestibility and intake of these feeds. During treating, the ammonia gas acts upon the fiber and favours the release of soluble carbohydrates and energy for cellulolytic bacteria growth, enhancing efficient utilization of roughages. Moreover, urea application is relatively easy, less toxic and effective (Ibrahim and Schiere, 1989).

The inputs needed for effective urea treatment should not follow blanket recommendation, as this is mainly influenced by the environmental conditions under which the treatment is carried out. However, under most tropical condition, 40 or 50 g of urea per kg of straw dissolved in as much as 1 kg of water has been used for urea treatment of roughages. Depending on the level of technology and the economy of the farmer, the ensiling vat for straw treatment with urea can vary from a simple pit to concrete silos. Dark brown colour of the straw with strong smell of ammonia and soft consistency are indicators of effective urea treatment (Mascarenhas-Ferreira et al., 1989).

Fafan Zone is among the dominant cereal-based farming practiced in SRS, where crop and livestock production are well integrated. Crop residue is utilized as livestock feed either as stubble grazing or is collected and used for stall feeding of livestock mostly during the dry season.

Agro-pastoralists accept that fibrous straws and stovers from cereal grain crops are a poor feed resource because their crude protein (CP) content is low and fiber levels are high. When offered to livestock both dry matter intake and palatability are low. However, these residues are often the only livestock feed available in smallholder mixed crop and livestock systems, especially in areas characterized by a defined dry season. This suggests that if these materials were used optimally, so that a

small improvement in the nutritive value was obtained, there would be a marked reduction in dry season feeding stress in livestock in the region.

The production and utilization of treated straw and stovers as supplementation to animals is feasible to improve the nutritional values and the productivity of farm animals. The present paper reports a laboratory experiment carried out to determine the effects of urea concentration and duration of ensiling treatment on chemical composition of straws and stovers by increasing digestibility, palatability and crude protein content. Therefore, experiment was carried out to evaluate and identify the most effective time of ensiling and urea treatment level to attain preferable nutritional aptitude.

MATERIALS AND METHODS

The experiment was conducted at Somali Region Pastoral and Agro-Pastoral Research Institute compound at Jigjiga. At higher elevation area and lower altitude of the study area the average monthly temperature varies between 16 to 20°C and 22 to 26°C, respectively, whereas the mean annual temperature is 21°C. The average annual rainfall ranged from 300 to 500 mm (MOARD-PADS, 2004).

Feed collection (WS, BS, MS and SS)

Wheat straw (WS) and barley straw (BS) were collected after grain harvest from Tulu Guled farmers. Sorghum stover (SS) and maize stover (MS) adequate for the experiment were collected from crop producing areas of Jigjiga surrounding. The collected residues (straw and stover) destined for treatments were sun-dried and stored without leaf-loss.

Urea treatment of the straw and stover

The straws and stovers were treated with 0.40 and 0.50 g concentration levels of urea solution prepared according to the result of MacMillan (1992) and Ibrahim and Schiere (1989), that is, each amount of urea were dissolved in 0.8 L of water.

After the sacks were sealed with air-tight plastic sheet, it was left unopened from one week up to four weeks. By the end of treatment period, the sacks were opened and the straw was aerated for 24 h and oven dried at 65°C for another 24 h. Finally, all the samples were taken to Holleta Research Center Nutrition Laboratory (HRCL) for chemical analyses. In addition, untreated straw and stover samples were also taken and pre-dried for parallel chemical analyses.

A two factor factorial design was used for the experiment. There were eight treatment combinations (two urea treatment at each of four durations of ensiling) and three replicate ensiled crop residues plastic sacks per treatment combination. This design was used for each crop residues (that is, wheat straw, barley straw, maize stover and sorghum stover).

Chemical analysis

Dry matter (DM), ash and Kjeldahl-nitrogen were determined according to the AOAC methods (AOAC 1990). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Van Soest and Robertson

Table 1. Chemical composition (%DM) of WS as affected by levels of urea and treatment duration.

Straw	DM	CP	NDF	ADF	OM	ADL	Ash	IVDMD
Untreated	93.42	3.91	79.65	56.2	91.23	9.74	8.77	45.24
	Effects of Urea level							
40 g Urea	92.19 ^a	5.26 ^a	68.36 ^a	52.22 ^a	91.74 ^a	8.19 ^a	8.26 ^a	58.56 ^a
50 g Urea	92.27 ^a	5.54 ^a	67.32 ^a	51.12 ^a	91.81 ^a	8.18 ^a	8.19 ^a	59.42 ^a
Wheat	Effect of treatment duration							
1st week	93.30 ^a	4.65 ^b	71.48 ^a	54.48 ^a	91.46 ^d	9.35 ^a	8.54 ^a	57.45 ^c
2nd week	92.15 ^b	4.77 ^b	69.68 ^b	52.88 ^b	91.67 ^c	8.43 ^b	8.33 ^b	57.84 ^{bc}
3rd week	92.10 ^b	5.87 ^a	66.23 ^c	49.88 ^c	91.82 ^b	7.87 ^b	8.18 ^c	59.04 ^b
4th week	91.38 ^b	6.30 ^a	63.98 ^d	49.43 ^c	92.15 ^a	7.10 ^c	7.85 ^d	61.63 ^a

^{ab}Means in the same column within each treatment factor bearing the same superscript are not significantly different at the 5% level. CP: crude protein; NDF: neutral detergent fibre; ADF: acid detergent fibre; ADL: acid detergent lignin DM: Dry matter; IVDMD: invitro dry matter digestibility. Source: Authors

(1985). Crude protein (CP) was calculated as N × 6.25. All the analyses were run in triplicates.

In vitro dry matter digestibility procedure

In vitro dry matter digestibility (IVDMD) of each samples were determined by the method of Tilley and Terry (1963). The rumen fluid was obtained from rumen fistulated animals kept at Holleta Research Station.

Data analysis

Data for *in vitro* DM digestibility were analyzed using the General Linear Models (GLM) procedure of the SAS program (SAS, 2002). Analyses followed a 2 × 4 factorial arrangement with amount of urea treatment and duration of ensiling as the main effects. Correlation among the different nutritional parameters was done. Means was separated using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

General observations

In the present experiment, two straws (wheat and barley) and two stovers (maize and sorghum) were treated with either 50 g urea or 40 g urea, regarded as two different urea levels and four durations of ensiling (7, 14, 21 and 28 days).

At the time of opening, there was no mould growth observed in each duration which leads to spoilage of the straws and stovers. The strength of NH₃ smell and the soft consistency was increased from the 1st to the 4th opening of the ensiled treated straws and stovers. All the treated crop residues were changed to golden brown on the 21st and 28th days of opening. Therefore, from the general observation, indicators insuring that the urea treatments were effective (Mascarenhas-Ferreira et al.,

1989).

Effects of urea level on WS and BS

The urea level had no-significant (P>0.05) effect on all chemical compositions for both urea treated straws (Tables 1 and 2). IVDMD was not also influenced by the concentration of urea. Therefore, treatment with 40 g urea may be more economical if it has good effect on intake of straws by the ruminant.

Effects of treatment duration on WS and BS

The CP content of WS increased significantly (P<0.05) over the treatment time, especially between 14th to 21st days. NDF fraction of the cell wall constituents was significantly (P<0.05) decreased between all treatment durations (7, 14, 21 and 28 days) from 71.48 to 63.98%, respectively. Both CP and ADF of the WS were not significantly (P>0.05) affected by the treatment time after 21 days (Table 1). Similar changes were observed in CP of WS following urea treatment (Getahun, 2006; Cakmak et al., 1996; Gao, 2000). However, the CP content of treated WS observed in this study was lower than that previously reported (Rehrahie, 2001). This reduction in CP was probably caused by volatile N loss while ventilating during sampling and drying before analysis.

Extending treatment time of the WS from 14 to 21 days did not affect the IVDMD and ADL (P>0.05), but further extending from 21 to 28 days significantly (P<0.05) increased the IVDMD from 59.04 to 61.63% and decreased ADL from 7.87 to 7.10% (Table 1). Rough calculations showed that, urea treatment improved digestibility of WS by 36% (from 45.24 to 61.63%).

In case of BS, urea-treatment significantly (P<0.05) increased CP content from 4.4 to 6.75% before and after

Table 2. Chemical composition (%DM) of BS as affected by levels of urea and treatment duration

Straw	DM	CP	NDF	ADF	OM	ADL	Ash	IVDMD
Untreated	93.2	4.4	76	49	90.7	9.81	9.3	46.34
Effects of Urea level								
40 g Urea	92.58 ^a	5.53 ^a	73.61 ^a	47.00 ^a	91.43 ^a	8.59 ^a	8.58 ^a	51.40 ^a
50 g Urea	92.46 ^a	5.66 ^a	73.13 ^a	46.78 ^b	91.47 ^a	8.38 ^a	8.53 ^a	51.98 ^a
Effect of treatment duration								
1 st week	92.64	4.54 ^d	75.65 ^a	48.43 ^a	90.80 ^c	9.41 ^a	9.21 ^a	47.34 ^d
2 nd week	92.09	4.86 ^c	74.20 ^{ab}	47.27 ^b	90.88 ^c	9.00 ^b	9.13 ^a	48.83 ^c
3 rd week	92.47	6.23 ^b	72.56 ^{bc}	46.64 ^c	91.43 ^b	8.30 ^c	8.58 ^b	54.78 ^b
4 th week	92.90	6.75 ^a	71.07 ^c	45.24 ^d	92.70 ^a	7.23 ^d	7.30 ^c	55.81 ^a

^{ab}Means in the same column within each treatment factor bearing the same superscript are not significantly different at the 5% level. CP: Crude protein; NDF: neutral detergent fibre; ADF: acid detergent fibre; ADL: acid detergent lignin; DM: dry matter; IVDMD: *in vitro* dry matter digestibility. Source: Authors

Table 3. Chemical composition (%DM) of MS as affected by levels of urea and treatment duration.

Stover	DM	CP	NDF	ADF	OM	ADL	Ash	IVDMD
Untreated	91.62	7.21	79.47	55.87	92.1	10.62	7.9	43.89
Effects of Urea level								
40 g Urea	91.94 ^b	7.99 ^a	77.31 ^a	53.08 ^a	93.34 ^a	9.86 ^a	6.66 ^a	49.65 ^a
50 g Urea	92.40 ^a	8.21 ^a	76.75 ^a	52.12 ^a	93.35 ^a	9.58 ^a	6.65 ^a	50.83 ^a
Effect of treatment duration								
1 st week	91.44 ^b	7.45 ^c	79.03 ^a	54.48 ^a	92.57 ^c	10.30 ^a	7.44 ^a	44.81 ^b
2 nd week	91.70 ^b	7.61 ^c	78.53 ^a	52.88 ^{ab}	92.74 ^c	10.56 ^a	7.27 ^a	49.82 ^{ab}
3 rd week	92.60 ^a	8.23 ^b	77.23 ^b	52.10 ^{bc}	93.20 ^b	9.75 ^b	6.80 ^b	51.25 ^a
4 th week	92.94 ^a	9.10 ^a	73.33 ^c	50.93 ^c	94.89 ^a	8.29 ^c	5.11 ^c	55.10 ^a

^{ab}Means in the same column within each treatment factor bearing the same superscript are not significantly different at the 5% level. CP: Crude protein; NDF: neutral detergent fibre; ADF: acid detergent fibre; ADL: acid detergent lignin DM: Dry matter; IVDMD: *in vitro* dry matter digestibility. Source: Authors

treatment, and NDF contents were significantly ($P < 0.05$) decreased between 7 and 28th days of treatment durations from 75.65 to 71.07%, respectively. ADF and ADL fractions of the cell wall constituents were significantly ($P < 0.05$) decreased between all treatment durations (7, 14, 21 and 28 days) from 48.43 to 45.24% and from 9.41 to 7.23%, respectively (Table 2). Treatment means of IVDMD of the BS were also significantly ($P < 0.05$) different at all treatment durations.

The IVDMD of BS was improved by 9.47% units when compared between untreated and treated. The increased IVDMD of urea treated straw could be explained by the improved concentration of digestible nutrients; by the enhanced accessibility of cell wall constituents to microbial digestion due to the disrupting effect of urea NH_3 on the chemical arrangement of cell wall constituents

and by dissolving out lignin which is believed to hinder the microbial digestion (Theander, 1981).

Effects of urea level MS and SS

There was no significant ($P > 0.05$) effect of urea level on the chemical composition and also IVDMD of urea treated MS and SS (Tables 3 and 4).

Effects of treatment duration on MS and SS

The results on chemical composition of MS value illustrated that the CP and OM content significantly increased ($P < 0.05$) and NDF and ADL fractions of the cell

Table 4. Chemical composition (%DM) of SS as affected by levels of urea and treatment duration.

Stover		DM	CP	NDF	ADF	OM	ADL	Ash	IVDMD
	Untreated	93.75	5.63	80.26	53.25	87.29	11.54	12.71	42.32
		Effects of Urea level							
	40 g Urea	93.10 ^a	6.00 ^a	77.15 ^a	52.56 ^a	88.23 ^b	10.85 ^a	11.78 ^a	50.31 ^a
	50 g Urea	92.93 ^b	6.15 ^a	76.90 ^a	52.38 ^a	88.37 ^a	10.76 ^a	11.63 ^b	50.46 ^a
Sorghum		Effect of treatment duration							
	1 st week	93.24 ^a	5.66 ^b	79.42 ^a	53.20 ^a	87.72 ^d	11.33 ^a	12.28 ^a	49.72 ^b
	2 nd week	93.34 ^a	5.75 ^b	78.53 ^a	52.71 ^b	87.88 ^c	10.91 ^b	12.13 ^b	50.19 ^b
	3 rd week	92.87 ^b	5.85 ^b	76.34 ^b	52.23 ^c	88.54 ^b	10.64 ^c	11.47 ^c	50.73 ^a
	4 th week	92.61 ^c	7.06 ^a	73.82 ^c	51.73 ^d	89.07 ^a	10.33 ^d	10.94 ^d	50.90 ^a

^{ab}Means in the same column within each treatment factor bearing the same superscript are not significantly different at the 5% level. CP: crude protein; NDF: neutral detergent fibre; ADF: acid detergent fibre; ADL: acid detergent lignin; DM: dry matter; IVDMD: *in vitro* dry matter digestibility.

Source: Authors

Table 5. Correlation coefficients of chemical composition and *in vitro* DM digestibility of WS.

Correlation	DM	CP	NDF	ADF	ADL	OM	IVDMD
CP	-0.72*	1					
NDF	0.86**	-0.95***	1				
ADF	0.80*	-0.95***	0.96***	1			
ADL	0.96***	-0.87**	0.95***	0.92**	1		
OM	-0.91**	0.90**	-0.97***	-0.90**	-0.97***	1	
IVDMD	-0.80*	0.90**	-0.94***	-0.84**	-0.88**	0.95***	1

CP: Crude protein; NDF: neutral detergent fibre; ADF: acid detergent fibre; ADL: acid detergent lignin OM: Organic matter; IVDMD: *in vitro* dry matter digestibility; * P<0.05, **P<0.01, *** P<0.001.

Source: Authors

wall constituents were significantly ($P<0.05$) decreased as the treatment duration advanced at 21st and 28th days (Table 3). Urea treatment improved the CP content of MS by about 26% (from 7.21 to 9.1%). On the other hand, the mean values of IVDMD showed significantly increase ($P<0.05$) from 7 to 28 days of treatment duration. Also digestibility of MS was improved by 11.21% units between untreated and treated from 43.89 to 55.1%, respectively.

At 7, 14 and 21 days of treatment duration, the CP content of the SS was not significantly increased ($P>0.05$), the 28th days treatment duration were significantly ($P<0.05$) different from the rest of the durations (Table 4). However, the CP increment between 21 and 28 days was 1.21% units compared to the 0.19% units between 7 and 21 days. Thus, the rate of CP increment appeared to slow down between 7 and 21 days of treatment duration. ADF and ADL were significantly ($P<0.05$) reduced between all treatment duration. The IVDMD were significantly increased ($P<0.05$) between 7 and 28 days but not between 7 and

14 or 21 and 28 days of treatment duration.

Correlation coefficient between nutritive value and *in vitro* DM digestibility of different crop residues

Correlation analysis for WS and BS

In urea treated WS and BS with different amount of urea and duration, Tables 5 and 6 present the correlation between the DM, CP, NDF, ADF, ADL, OM and IVDMD.

Negative correlations were detected between IVDMD and fiber fractions (ADF, NDF and ADL) for both WS and BS. Numerous evidences (Van Soest et al., 1991; McDonald et al., 1995; Buxton, 1996) indicated that high cell wall constituents also set a limit to potential feed intake by physical fill effect as well as by reducing the digestibility of feeds.

The correlation coefficient between the CP and cell wall contents such as NDF, ADF and ADL indicated negative values of -0.95, -0.95 and -0.87 and -0.97, -0.93 and -

Table 6. Correlation coefficients of chemical composition and in vitro DM digestibility of BS.

Correlation	DM	CP	NDF	ADF	ADL	OM	IVDMD
CP	0.49	1					
NDF	-0.41	-0.97***	1				
ADF	-0.37	-0.93***	0.96***	1			
ADL	-0.52	-0.95***	0.96***	0.98***	1		
OM	0.62	0.90**	-0.90**	-0.93***	-0.97***	1	
IVDMD	0.43	0.99***	-0.95***	-0.91**	-0.92**	0.86**	1

CP: Crude protein; NDF: neutral detergent fibre; ADF: acid detergent fibre; ADL: acid detergent lignin
OM: Organic matter; IVDMD: *in vitro* dry matter digestibility; * P<0.05, **P<0.01, *** P<0.001.
Source: Authors

Table 7. Correlation coefficients of chemical composition and in vitro DM digestibility of SS.

Correlation	DM	CP	NDF	ADF	ADL	OM	IVDMD
CP	-0.82*	1					
NDF	0.92**	-0.90**	1				
ADF	0.89**	-0.85**	0.97***	1			
ADL	0.85**	-0.81*	0.94***	0.99***	1		
OM	-0.96***	0.87**	-0.98***	-0.97***	-0.95***	1	
IVDMD	-0.85**	0.70	-0.89**	-0.96***	-0.97***	0.92**	1

CP: Crude protein; NDF: neutral detergent fibre; ADF: acid detergent fibre; ADL: acid detergent lignin;
OM: organic matter; IVDMD: *in vitro* dry matter digestibility; * P<0.05, **P<0.01, *** P<0.001.
Source: Authors

Table 8. Correlation coefficients of chemical composition and in vitro DM digestibility of MS.

	DM	CP	NDF	ADF	ADL	OM	IVDMD
CP	0.90**						
NDF	-0.84**	-0.98***					
ADF	-0.91**	-0.86**	0.85**				
ADL	-0.86**	-0.95***	0.98***	0.80*			
OM	0.80*	0.96***	-0.99***	-0.79*	-0.96***		
IVDMD	0.89**	0.83*	-0.84**	-0.95***	-0.79*	0.81*	1

CP: Crude protein; NDF: neutral detergent fibre; ADF: acid detergent fibre; ADL: acid detergent lignin; OM: organic matter;
IVDMD: *in vitro* dry matter digestibility; * P<0.05, **P<0.01, *** P<0.001.
Source: Authors

0.95 for WS and BS, respectively. While other quality parameters such as IVDMD and CP were correlated with correlation coefficient value of $r=0.90$ ($P<0.01$) for WS and $r=0.99$ ($P<0.001$) for BS.

Correlation analysis for MS and SS

In the urea treated MS and SS with different amount of urea and duration, Tables 7 and 8 present the correlation between the DM, CP, NDF, ADF, ADL, OM and IVDMD. The positive correlation was observed between IVDMD

and CP levels in both MS and SS, but not statistically significant for SS. Negative and significant ($P<0.05$) linear correlations were observed between IVDMD and fiber fractions (NDF, ADF and ADL), respectively, for both MS and SS.

Conclusions

The goal of this study was to determine the most effective ensiling time and urea treatment amount for achieving preferred nutritional aptitude. Therefore, the

commencement of urea treatment of straws and stovers resulted in no mold growth, a golden brown hue, a soft consistency, and a strong ammonia odor, indicating that the treatment was effective. It also improves the nutritive value of the treated crop residues, in terms of total content and *in vitro* digestibility.

On the basis of the current findings, it can be stated that the urea level had no effect on the chemical compositions and IVDMD for all urea-treated straws and stovers. As a result, treatment with 40 g urea may be more cost-effective. The study also found that if the ambient temperature is between 16 and 20°C, the treatment period for both straws and stovers should be 28 days.

Finally, urea treatment is recommended technologies for resource poor smallholder agro-pastoralists who cannot afford the use of commercial supplementation. However, to generate more information supporting the current result, further work is suggested in supplementation of urea treated straws and stovers based feeding for livestock.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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