

## Nutritive Value of Urea Treated Wheat Straw Ensiled with or without Corn Steep Liquor for Lactating *Nili-ravi* Buffaloes

Mahr-un-Nisa, M. Sarwar\* and M. Ajmal Khan

Department of Animal Nutrition, University of Agriculture, Faisalabad, Pakistan

**ABSTRACT :** Influence of different levels of corn steep liquor (CSL) on chemical composition of urea treated wheat straw (UTWS) and its dietary effect on nutrient intake, digestibility, milk yield and its composition were studied. The 5% UTWS was ensiled with 0, 3, 6 and 9% CSL on dry matter (DM) basis. Total nitrogen and neutral detergent fiber (NDF) contents of UTWS ensiled with 0, 3, 6 and 9% CSL increased linearly with the increasing level of CSL. Increase in NDF content was due to increased neutral detergent insoluble nitrogen contents. Four experimental diets were formulated to contain 35% UTWS ensiled without CSL (control), 45 (WS45), 55 (WS55) and 65% (WS65) UTWS ensiled with 9% CSL, respectively. Dry matter, NDF and acid detergent fiber (ADF) intakes by lactating buffaloes fed diets containing varying levels of UTWS ensiled with or without CSL remained similar across all treatments. However, DM, NDF and ADF intakes as a percent of body weight and digestible DM, NDF and ADF intakes were higher in animals fed WS65 diet compared to those fed other diets. Apparent DM, crude protein (CP), NDF and ADF digestibilities were higher in diets containing UTWS ensiled with CSL compared to control. These differences may be attributed to higher rates of degradability of UTWS ensiled with 9% CSL than that ensiled without CSL. The 4% fat corrected milk and CP were statistically higher with WS65 diet compared to other diets. Percent milk fat, solid not fat and total solid remained unchanged across all treatments. (*Asian-Aust. J. Anim. Sci.* 2004, Vol 17, No. 6 : 825-829)

**Key Words :** Urea, Corn Steep Liquor, Wheat Straw, Milk Production, Buffaloes

### INTRODUCTION

Crop residues especially wheat and rice straws are being recognized most important contributors to dairy diets in developing regions of the world (Mehra et al., 2001). However, their poor nutrient balance and digestibility limit the performance of animals. These feeds are characterized by high content of indigestible fiber due to increased lignification of cellulose that ultimately causes the reduction in digestibility. This lower digestibility limits the intake because of gut fill effect and thus, reduces the feed utilization by ruminants. Moreover, animals thriving on such type of feeds pose a potential threat to the environment due to increased eructation of green house gases (Sarwar and Ali, 2000).

It is imperative to enhance the feeding value of these low quality straws through various biological, physical and chemical treatments. Among various chemicals employed for upgrading fibrous feed, ensilation of straws with urea is considered practicable because it is much safer to handle and easier to transport than either anhydrous or aqueous  $\text{NH}_3$  (Ali et al., 1993). However, ammoniation through urea treatment increases the pH of the treated material and this increased pH does not only cause nitrogen (N) loss that escapes to the environment but it also causes asynchrony between available N and energy at ruminal level. It has been reported that about 60-70% free ammonia ( $\text{NH}_3$ )

released from urea treatment goes to the atmosphere and about 30% is retained in the treated material (Taiwo et al., 1995; Dass et al., 2001).

Many efforts have been made to fix  $\text{NH}_3$ -N in fibrous feed using various organic and inorganic acids (Borhami et al., 1982; Yadav and Virk, 1994; Dass et al., 2000; Dass et al., 2001). However, fixing excess  $\text{NH}_3$  with acid is costly and hazardous and thus, its use by farmers is impracticable. The corn steep liquor (CSL) may offer a solution to the problem of escaping  $\text{NH}_3$  and poor fermentation of urea treated wheat straw (UTWS). Because it does not only contain easily soluble carbohydrates, which can improve fermentation, but it also contains 20% lactic acids (Table 1), which may help to fix the excess  $\text{NH}_3$ . However, the scientific evidence regarding its dietary effects on performance of lactating buffaloes is limited. Therefore, the present study was planned to evaluate different levels of UTWS with or without CSL on feed intake, milk yield and its composition and digestibility in buffaloes.

### MATERIALS AND METHODS

#### Laboratory silos

Wheat straw was ground through a Wiley mill (2 mm screen) and was treated with urea and a ratio of wheat straw dry matter (DM): water: urea was 100:50:05. The CSL was added to the UTWS at 0, 3, 6 and 9% on DM basis. The chemical composition of CSL is shown in Table 1. This treated wheat straw was ensiled in laboratory silos for 5, 10 and 15 days. Because of three different storage durations,

\* Corresponding Author: M. Sarwar. Tel: +92-41-960161-170 (3205), E-mail: sarwar041@hotmail.com

Received August 7, 2003; Accepted February 12, 2004

**Table 1.** Chemical composition of corn steep liquor

Items	Concentration
Dry matter, %	50
Protein, %	40
Ash, %	10
Nitrogen free extract, %	16
pH	3.7
Lactic acid, %	21
Specific gravity	1.25

three laboratory silos per mixture were prepared and were sealed and stored in the incubator at 40°C. The samples of this fermented wheat straw were analyzed for DM, organic matter (OM), neutral detergent insoluble nitrogen (NDIN), acid detergent insoluble nitrogen (ADIN), N and ash by the methods of AOAC (1990), neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) by methods described by Van Soest et al. (1991). Chemical composition of UTWS ensiled with or without CSL is given in Table 2.

#### Treatment of wheat straw

The urea treatment method used in performance trial was to add 5 kg urea and 50 kg water per 100 kg air-dry wheat straw. After the urea was dissolved in the water, the solution was uniformly sprayed on the wheat straw. Then the wheat straw was put into two different cemented pits and ensiled for a period of 15 days with air temperatures of 35-45°C. In the control pit, the wheat straw was treated with 5% urea only. In the second pit, 9% CSL on dry matter basis was added to the 5% UTWS. Each pit was covered with 15 mm thick layer of rice straw, followed by plastic film covering which was plastered with a blend of wheat straw and mud to avoid any cracking on drying. The treated material was allowed to react for 15 days, it was assumed that plastic film, and mud plastering provided anaerobic conditions for proper silage making. When the feed was used, the plastic film was removed and the feed withdrawn starting with the upper layer and working downwards to the lower layers. An amount of the fermented straw was taken

**Table 3.** Ingredients and chemical composition of diets fed to lactating buffaloes

Ingredients	Diets <sup>1</sup>			
	WS 35	WS 45	WS 55	WS 65
Wheat straw	35	45	55	65
Cane molasses	8.9	9	9	9
Wheat bran	9	7	1	0
Sunflower meal	20	18	26	7
Maize oil cake	20	16	2	0
Cotton seed meal	4	0	0	10
Berga fat <sup>2</sup>	0.1	2	4	6
Mineral mixture	2	2	2	2
Salt	1	1	1	1
Chemical composition, %				
DM	89.3	89.5	89.9	90.7
OM	89.5	89.5	89.7	89.7
CP	14.8	14.8	15.0	15.3
NDF	47.9	50.8	51.9	52.1
ADF	28.0	30.0	34.0	34.0
ADL	7.8	8.7	10.9	10.6
EE	2.1	3.7	5.4	7.8
NE <sub>L</sub> , Mcal/kg	1.43	1.42	1.42	1.41

<sup>1</sup> WS35 contained 35% urea treated wheat straw ensiled without CSL, while WS45, WS55 and WS65 contained 45, 55 and 65% urea treated wheat straw ensiled with 9% CSL, respectively.

<sup>2</sup> Ruminally protected fat.

out just sufficient for one day's feeding after being taken from the pit and the plastic film was put back to keep the pit sealed. The samples of this fermented wheat straw was analyzed for DM, OM, N, NDF, ADF by methods described above.

#### Animals and diets

Sixteen early lactating *Nili-Ravi* buffaloes, four animals in each group, were used in a Completely Randomized Design to evaluate the effect of varying levels of 5% UTWS ensiled with or without CSL on feed intake, digestibility and milk production and its composition. Animals were housed on a concrete floor in separate pens. Buffaloes averaged 30±5 days in lactation were used in this experiment. Four experimental diets were formulated (Table

**Table 2.** Influence of varying levels of corn steep liquor (CSL) on chemical composition of urea treated wheat straw

Items	Treatments <sup>1</sup>				SE	Probabilities		
	Control	CSL 3	CSL 6	CSL 9		Linear	Quadratic	Cubic
Total N	1.03	1.55	1.83	2.17	0.8	0.01	NS	NS
NH <sub>3</sub> -N	0.72	0.78	0.85	0.85	7	0.01	NS	NS
NDIN <sup>2</sup>	0.40	0.65	0.75	0.95	5	0.01	NS	NS
ADIN <sup>3</sup>	0.32	0.33	0.33	0.35	3	0.01	NS	NS
Remainder-N	0.25	0.41	0.45	0.51	4	0.01	NS	NS
NDF <sup>4</sup>	74.01	76.16	77.74	78.93	7	0.01	NS	NS
CP-free NDF <sup>5</sup>	71.51	72.10	73.10	72.99	7	NS	NS	NS
ADF	47.69	47.70	46.76	45.94	5	0.01	NS	NS
Cellulose	36.48	35.99	34.95	34.06	4	NS	NS	NS

<sup>1</sup> Control, CSL 3, CSL 6, CSL 9 treatments represents 5% urea treated wheat straw ensiled with 0, 3, 6 and 9% CSL, respectively.

<sup>2</sup> NDIN neutral detergent insoluble nitrogen. <sup>3</sup> ADIN acid detergent insoluble nitrogen.

<sup>4</sup> Neutral detergent fiber. <sup>5</sup> Crude protein free NDF was calculated as (NDF-NDIN×6.25).

3). Wheat straw ensiled with urea and urea plus 9% CSL was the roughage used in the experimental diets. The control ration was balanced to contain 35% UTWS without CSL. Wheat straw 45, 55 and 65 diets were formulated to have 45, 55 and 65% UTWS ensiled with 9% CSL, respectively. All diets were formulated to be iso-nitrogenous and iso-energetic using NRC (2001) values for energy and protein. Diets were mixed daily and fed twice a day at *ad libitum* intakes.

The buffaloes were fed for 90 days. The first 10 days were allowed for dietary adaptation and 80 days were for sample collection. Daily feed intake and milk production were averaged over 80 days. Milk samples (a.m. and p.m.) were collected twice weekly during the last 80 days of feeding trial and were analyzed for crude protein (CP), fat, solid not fat, total solids and ash by the methods described by AOAC (1990). During the last week of the trial, a digestibility trial was conducted. The acid insoluble ash was used as digestibility marker (Van Keulen and Young, 1977). Fecal grab samples were taken twice daily such that a sample was obtained for every 3 h interval of 24 h period (8 samples) between am and pm feedings (Sarwar et al., 1991). Feed offered andorts were sampled daily and composited by animal for analysis. Diets, orts and fecal samples were analyzed for DM, OM and CP (AOAC, 1990) for NDF (Van Soest, 1991), ADF and ADL (Goering and Van Soest, 1970) for estimation of NE<sub>L</sub> (Conrad et al., 1984).

#### Statistical analysis

The ANOVA and trend comparisons were made to see the linear quadratic and cubic responses using the GLM procedure of SAS (1988). The data collected on different parameters (feed intake, milk production, milk composition and digestibility of DM, OM, NDF, ADF, CP and EE) were analyzed according to Completely Randomized Design. The difference in means was tested using Duncan's Multiple Range test (Steel and Torrie, 1984). Significance at  $p < 0.05$

was used throughout unless otherwise noted.

## RESULTS AND DISCUSSION

#### Chemical composition of wheat straw

Chemical composition of UTWS ensiled with or without CSL is given in Table 3. Nitrogen contents of UTWS ensiled with or without CSL were linearly increased with increasing level of CSL. The UTWS ensiled with 3, 6, and 9% CSL have increased 50, 78 and 111% N when compared with control. The higher N content of UTWS ensiled with CSL may be because of high lactic acid content of CSL (Table 1). However, the provision of readily available nutrients (carbohydrates, minerals and proteins) for the proper fermentation milieu by the CSL might have caused a further drop in pH of the UTWS. This reduced pH probably has changed free ammonia (NH<sub>3</sub>) released from urea into an ionic form of ammonia (NH<sub>4</sub><sup>+</sup>) that is very reactive and has the greater tendency to make bonds with fibrous materials. In consistent with the present findings higher N values in ammoniated straw were reported by different workers who trapped the excess free NH<sub>3</sub> by spraying organic acids (Sarwar et al., 2003), inorganic acids (Taiwo et al., 1995) or using non-structural carbohydrates (Sarwar et al., 1994). Significant ( $p < 0.05$ ) linear increase was noted in NDIN and ADIN contents of UTWS ensiled with different levels of CSL. The percent retained of the added urea N as NDIN was 48, 44, 48% when UTWS was ensiled with 3, 6 and 9% CSL. The concentration of NDIN was approximately 1.6 (0.25 percentage units), 1.8 (0.35 percentage units) and 2.4 (0.55 percentage units) times higher in 3, 6 and 9% CSL compared to UTWS without CSL. The NDF and ADF contents of UTWS ensiled with different levels of CSL increased linearly with the increasing level of CSL. The increase in NDF is because of increased NDIN when NDF was calculated on a CP free basis (NDF-NDIN $\times$ 6.25), its concentration remained unaltered between UTWS ensiled

**Table 4.** Nutrient intake and digestibility by buffaloes fed diets containing urea treated wheat straw with or without corn steep liquor (CSL)

Items	Treatments <sup>1</sup>				SE
	WS 35	WS 45	WS 55	WS 65	
Dry matter intake (kg/day)	11.9	11.6	11.2	11.9	0.50
Apparent DM digestibility (%)	69.8 <sup>a</sup>	61.9 <sup>d</sup>	63.7 <sup>c</sup>	65.0 <sup>b</sup>	0.39
DMI (%BW)	2.6 <sup>a</sup>	2.4 <sup>b</sup>	2.2 <sup>b</sup>	2.5 <sup>a</sup>	0.06
CP intake (kg/day)	1.70	1.72	1.68	1.70	0.04
Apparent CP digestibility (%)	65.4 <sup>d</sup>	67.0 <sup>c</sup>	67.7 <sup>b</sup>	71.5 <sup>a</sup>	0.18
EE intake (kg/day)	0.25 <sup>d</sup>	0.43 <sup>c</sup>	0.61 <sup>b</sup>	0.86 <sup>a</sup>	0.02
Apparent EE digestibility (%)	79.8	79.9	80.3	79.6	0.37
NDF intake (kg/day)	5.9	5.9	5.8	5.9	0.18
NDF digestibility (%)	50.4 <sup>d</sup>	52.9 <sup>c</sup>	54.1 <sup>b</sup>	60.5 <sup>a</sup>	0.26
ADF intake (kg/day)	3.4	3.5	3.8	3.8	0.09
ADF digestibility (%)	43.9 <sup>d</sup>	46.4 <sup>c</sup>	50.2 <sup>b</sup>	59.2 <sup>a</sup>	0.3

<sup>1</sup> WS 35 contained 35% urea treated wheat straw ensiled with 0% CSL and WS45, WS55 and WS65 contained 45, 55 and 65% urea treated WS ensiled with 9% CSL, respectively.

Means in the same row having different superscripts differ significantly at ( $p < 0.05$ ).

with or without CSL. Chemical composition of UTWS ensiled with different levels of CSL was not affected by the fermentation time. No interaction between time and treatment effect was noted on chemical composition of wheat straw.

### Feed intake

Dry matter, NDF and ADF intakes by lactating buffaloes fed diets containing varying levels of UTWS ensiled with or without CSL remained similar across all treatments (Table 4). However, DM, NDF and ADF intakes as a percent of body weight and digestible DM, NDF and ADF intakes were higher in animals fed diets containing 65% (WS65) UTWS ensiled with 9% CSL when compared to those fed on other diets. This significant variation in digestible DM, ADF and NDF intakes can be attributed to ensilation of UTWS with CSL that might have caused significant changes in its degradability and digestibility (Nisa et al., 2003; Sarwar et al., 2003). The percentage of UTWS ensiled with or without CSL was different in each diet, which was expected to make much changes in the gut fill by altering lag time, rate of disappearance and extent of digestion of different feed fractions (Sarwar et al., 1991; Sarwar et al., 1994). Crude protein intake remained unaltered across all treatments. Similar trend was noted in the intake of digestible CP, which supported the findings of Misra et al. (2000). Ether extract (EE) and digestible intakes significantly differed among all treatments. Intake of EE was the highest in animals fed WS65 diet when compared to those fed WS55, WS45 and WS35 diets. This difference may be attributed to the variation in proportion of fat that was added into different diets to make them iso-caloric (Table 3). Sarwar et al. (2004) reported that the lack of difference in intake can be ascribed to both the enhanced fiber digestibility of corncobs treated with CSL and urea and addition of ruminally inert fat that not only remained largely unavailable in the rumen because of its low solubility and high melting point but it could not also impair ruminal fiber digestibility that possibly affects the distension of rumen that can limit the DMI.

### Digestibility

Apparent DM, CP, NDF and ADF digestibilities were

significantly ( $p < 0.05$ ) higher in diets containing UTWS ensiled with CSL than control. These differences may be attributed to higher rates of degradability of UTWS ensiled with 9% CSL than that ensiled without CSL (Nisa et al., 2003). Increased digestibility of UTWS ensiled with CSL probably involved the breakage of alkali-labile bonds in the wheat straw fiber (Ali et al., 1993). It might be the result of ammoniolysis of galacturonic acid esters attached to the xylan chains of hemicellulose. Ammoniation in combination with CSL treatment might have sponified esters bonds between lignin and hemicellulose and saturates H-bonds linking the matrix polysaccharides and thus improve the degradability and digestibility of DM and NDF. Further, the decreasing percentage of NDF from UTWS in WS35 diet might have caused the reduction in ruminal pH, that might have slowed down the activity of cellulolytic microbes (Sarwar et al., 1992). Increased levels of ruminal escaped protein might have improved apparent CP digestibility in WS65 diet when compared to WS55, WS45 and WS35 diets. The EE digestibility remained unchanged across all treatments.

### Milk yield and composition

The 4% fat corrected milk was statistically significant ( $p < 0.05$ ) across all treatments. The higher milk production by buffaloes fed WS65 and WS55 diets was because of increased digestible NDF intake. The WS65 and WS55 diets contained higher amounts of ruminally un-degradable protein in combination with rumen-protected fat that digested in lower alimentary canal. This might have provided a better synchronization of nutrients at cellular level that helps synthesize more milk. A tendency for a linear increase in milk production by buffaloes fed diets with decreasing nonstructural carbohydrates (NSC) concentration may be attributed to increasing ruminally-protected fat in the diet to maintain  $NE_L$  in the experimental diets. Sarwar et al. (2004) reported that milk production was increased when ruminally protected fat was added in the dairy diets contained urea treated corncobs treated with CSL and urea they attributed this increase in milk production to higher amount of both ruminally un-degradable protein and inert fat which might have provided a better nutrient synchronization at cellular level and thus

**Table 5.** Milk yield and composition by buffaloes fed diets containing urea treated wheat straw with or without corn steep liquor (CSL)

Items	Treatments <sup>1</sup>				SE
	WS 35	WS 45	WS 55	WS 65	
Milk yield, 4% FCM (kg/day)	10.64 <sup>a</sup>	13.20 <sup>b</sup>	12.91 <sup>b</sup>	13.49 <sup>b</sup>	1.42
Milk fat (%)	7.12	6.38	6.99	7.05	0.29
Solids not fat (%)	9.22	9.50	9.26	9.05	0.10
Total solids (%)	15.95	16.34	16.50	15.37	0.36
Crude protein (%)	3.55 <sup>b</sup>	3.62 <sup>b</sup>	3.93 <sup>a</sup>	3.97 <sup>a</sup>	0.07
True protein (%)	3.07	3.15	3.08	3.24	0.05
Non protein nitrogen (%)	0.55	0.50	0.85	0.74	0.09

<sup>1</sup>WS 35, 45, 55 and 65 contain 35% urea treated WS without CSL and 45, 55 and 65% contain urea treated WS with 9% CSL.

Means in the same row having different superscripts differ significantly at ( $p < 0.05$ ).

helped to synthesize more milk.

Percent CP in milk of buffaloes was different ( $p < 0.05$ ) across all diets. Milk protein percentage in cows fed diets decreasing in NSC and increasing in added fat often depresses milk protein percentage without altering protein yield, partly because of changes in post absorptive metabolism (Sarwar et al., 1992). The increased CP contents in the milk of buffaloes fed WS65 and WS55 diets may be attributed to increased bypass protein supplied in these diets when compared to WS45 and WS35 diets. This increased bypass protein might have supplied amino acids in proper proportion and amount for milk protein synthesis. Results of metabolic trials (Nisa et al., 2003) revealed that total, viable, cellulolytic and bacterial count per ml was higher in animals fed diets containing UTWS ensiled with CSL when compared to those fed diets containing UTWS ensiled with 0% CSL. An increase in cellulolytic population after feeding of diets containing UTWS ensiled with CSL indicated proper synchronization and utilization of nutrients at ruminal level as previously reported by Kanjanapruthipong and Leng (1998). The improved synchronization and utilization of N from CSL and UTWS for milk protein synthesis was also supported by the highest milk CP as a percentage of total CP intake in animals fed WS65 and WS55 diets. Percent milk fat, solid not fat and total solid remained unchanged across all treatments.

## CONCLUSION

Ensilation of UTWS with CSL improves the N retention in the urea treated material and feeding of UTWS ensiled with 9% CSL to lactating buffaloes improve the nutrient digestibility and thus milk yield.

## REFERENCES

- Ali, C. S., M. Sarwar, R. H. Siddiqi, R. F. Hussain, T. Khaliq, S. U. R. Chaudhry and A. R. Barque. 1993. Effect of urea treatment of wheat straw on disappearance and rate of passage through reticulo-rumen of buffalo. *Pak. Vet. J.* 13:74.
- AOAC. 1990. Official Methods of Analysis. Association of Analytical Chemists, 15th Ed. Arlington Virginia, USA.
- Borhami, B. E. A., F. Sundstol and T. H. Garmo. 1982. Studies of ammonia treated straw. Fixation of ammonia treated straw by spraying with acids. *Anim. Feed Sci. Technol.* 7:53.
- Conrad, H. R., W. P. Weiss, W. O. Odwongo and W. L. Shockey. 1984. Estimating net energy lactation from components of cell solubles and cell walls. *J. Dairy Sci.* 67:427.
- Dass, R. S., U. R. Mehra and A. K. Verma. 2000. Nitrogen fixation and in situ dry matter and fiber constituent disappearance of wheat straw treated with urea and boric acid in murrah buffaloes. *Asian-Aust. J. Anim. Sci.* 13:1113.
- Dass, R. S., A. K. Verma, U. R. Mehra and D. S. Saker. 2001. Nutrients utilization and rumen fermentation pattern in murrah buffaloes fed urea and urea plus hydrochloric acid treated wheat straw. *Asian-Aust. J. Anim. Sci.* 14:1542.
- Goering, H. G. and P. J. Van Soest. 1970. Forage Fiber analysis. *Agricultural Handbook* 379, USDA.
- Kanjanapruthipong, J. and R. A. Leng. 1998. The effects of dietary urea on microbial populations in the rumen of sheep. *Asian-Aust. J. Anim. Sci.* 11:661.
- Mehra, U. R., R. S. Dass, A. K. Verma and D. S. Sabu. 2001. Effect of feeding urea and acetic acid treated wheat straw on the digestibility of nutrients in adult murrah buffaloes (*Babulus bubalis*). *Asian-Aust. J. Anim. Sci.* 14:1690.
- Misra, A. K., S. A. Karim, D. L. Verma, A. S. Misra and M. K. Tripathi. 2000. Nutrient intake, its utilization, rumen fermentation pattern and blood bio-chemical constituents of sheep fed urea treated mustard straw. *Asian-Aust. J. Anim. Sci.* 12:1674.
- Nisa M., M. Sarwar and M. A. Khan. 2003. Influence of corn steep liquor on nitrogen fixation in urea treated wheat straw and in situ digestion kinetics in ruminally cannulated buffalo bulls. *Anim. Feed Sci. Technol.* (accepted).
- NRC. 2001. Nutrient requirements of dairy cattle. 7th revised edition. National Academy Press, Washington, DC.
- Sarwar, M., M. A. Khan and M. Nisa. 2004. Influence of ruminally protected fat and urea treated comcobs on nutrient intake, digestibility, milk yield and its composition in *Nili-Ravi* buffaloes. *Asian-Aust. J. Anim. Sci.* 17(1):86.
- Sarwar, M., M. A. Khan and M. Nisa. 2003. Nitrogen retention and chemical composition of urea treated wheat straw ensiled with organic acids or fermentable carbohydrates. *Asian-Aust. J. Anim. Sci.* 16(11):1563.
- Sarwar, M. and C. S. Ali. 2000. The rumen: Digestive physiology and feeding management. *Friends Sci. Publishers.* 399-B, Peoples Colony No. 1, Faisalabad, Pakistan.
- Sarwar, M., J. L. Firkins and M. L. Estridge. 1992. Effects of varying forage and concentrate carbohydrates on nutrient digestibilities and milk production by dairy cows. *J. Dairy Sci.* 75:1533.
- Sarwar, M., M. A. Iqbal, C. S. Ali and T. Khaliq. 1994. Growth performance of buffalo male calves as affected by using cowpeas and soybean seeds as a source of urease during UTWS ensiling process. *Egyptian J. Anim. Prod.* 2:179.
- Sarwar, M., J. L. Firkins and M. L. Estridge. 1991. Effect of replacing neutral detergent fibre of forage with soy hulls and corn gluten feed for dairy heifers. *J. Dairy Sci.* 74:1006-1014.
- SAS. 1988. Statistical Analysis System. SAS user's guide: Statistics, SAS Inst. Inc., Cary, NC.
- Steel, R. G. D. and J. H. Torrie. 1984. Principles and Procedures of Statistics. A Biometrical Approach (2nd Ed). McGraw Hill Book Co. Inc., New York, USA.
- Taiwo, A. A., E. A. Adebowale, J. F. D. Greenhalgh and A. O. Akinsoyinu. 1995. Techniques for trapping ammonia generated from urea treatment of barley straws. *Anim. Feed Sci. Technol.* 56:133.
- Van Keulen, J. and B. A. Young. 1977. Evaluation of acid-insoluble ash as a natural marker in ruminant digestibility studies. *J. Anim. Sci.* 44:282.
- Van Soest, P. J., H. B. Robertson and B. A. Lewis. 1991. Methods of dietary fiber, NDF and non-starch polysaccharides in relation to animal material. *J. Dairy Sci.* 74:3583.
- Yadav, B. S. and A. S. Virk. 1994. The fixation of nitrogen using acid green forages and germinated barley during urea treatment of straw. *Anim. Feed Sci. Technol.* 50:123.