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Development of on-farm mechanized urea treatment process during threshing and utilization of urea treated wheat straw in lactating *Murrah* buffaloes (*Bubalus bubalis*)

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Abstract
The present study was conducted to mechanize the urea treatment method during threshing and subsequently, the treated straw was nutritionally evaluated in lactating *Murrah* buffaloes for a period of 90 days. The cost of urea treatment of straw in mechanized process was only Rs 26 per quintal. Buffaloes had comparable dry matter intake (DMI) on untreated and urea treated diets, however, roughage intake was significantly (P<0.05) higher in UTWS group than UWS group. The nutrient intake (kg/day) in terms of digestible crude protein (DCP) and ME (M cal/ day) from composite diet was comparable in both the groups. Buffaloes had similar DM, OM and CP digestibility on both types of diets. However, buffaloes had higher (P<0.05) NDF (53.40 vs 48.91%) and ADF (51.18 vs 46.46%) digestibility on UTWS diet than UWS diet. Milk yield (6% FCM) by buffaloes fed UWS and UTWS diets was similar. The percent milk fat, CP, TS and SNF were also non-significant (P>0.05) on both the groups. Based on market milk price of Rs 30/kg, buffaloes fed UTWS diet had higher (P<0.05) net return (Rs 11.63 vs 9.23 /kg milk) compared to UWS diet. It was concluded that bulk quantity of straw can be treated simultaneously with urea without disturbing existing threshing mechanism and farmers need not to spent any additional labour and time for urea treatment. Feeding of urea treated straw not only economized the diet of lactating buffaloes but also increased straw intake leading to better use of straw offered.

Keywords: Mechanization, *Murrah* buffaloes, Nutrient utilization, Urea treatment process, Wheat straw

Abbreviations: ADF: Acid detergent fiber; **CP**: Crude protein; **DCP**: Digestible crude protein; **DM**: Dry matter; **DMI**: Dry matter intake; **ME**: Metabolizable energy; **OM**: Organic matter; **NDF**: Neutral detergent fiber; **SNF**: Solid not fat; **TDN**: Total digestible nutrient

Introduction

In India the ruminant production system is solely based on crop residues like straws, stovers etc. (Kumar *et al*., 2014) and meager amount of concentrate supplements. However, the utilization of these crop residues in livestock is poor due to low availability of protein and energy (Singh *et al*., 2010). Straw treatment with urea offers great potential as it not only improves the quality of straw by breaking the ligno-cellulosic bond but also increases the nitrogen content (Chriyaa *et al.,* 1997). However, its adoption at farmer's level is very poor due to the difficulty being faced by farmers to carry out the technical job unaided and high labour cost involved in spreading, sprinkling of urea solution and heap making. Hence, suitable methodology was required to be developed that ensure application of urea during threshing, then these straws/ crop residues can be converted into value added feed in bulk quantity. Keeping in view the above, present investigation was carried out to mechanize urea treatment during threshing and subsequently the treated straw was nutritionally evaluated in lactating *Murrah* buffaloes.

Materials and Methods

Urea treatment of straw: Commercially available thresher in the market was used for urea treatment of wheat straw during threshing. Thresher was tested for its capacity in view to decide the requirement of urea solution to be sprayed for treatment of straw and selection of nozzles and pump. The thresher was operated by 45 HP tractor and had the capacity in the range of 7 to 8 q/h at tractor RPM range of 1400 to 1600. The two outlets of this conventional thresher were merged into a single outlet in order to collect all straw through a single place and for easy and uniform treatment of the straw. A plunger pump was fixed on the thresher. Two nozzle guns with capacity of 3-4 liter/minute were fixed at both the sides of straw outlets. A water tank of 1000 liter capacity was attached to store the urea solution (4 kg urea dissolved per 50 liters of water for 100 kg straw treatment) to be used for spraying during threshing. The stock solution was kept in 1000 litres plastic tank and supplied to the nozzles (2 Nos.) through a pressure hose (inlet) connected to a plunger pump (three piston)

and a rubber pipe (outlets). The plunger pump was mounted on the thresher and two nozzles were placed on specially designed single straw outlet. The straw outlet was bolted on the thresher in such a way that it confines the already built two straw outlets provided by manufacturer and all the straw generated after threshing carried out with the air through this specially designed single outlet. Adjustable valves were fitted with nozzles to control spraying rate of the urea solution.

To operate the pump for initiating spray of urea solution, the power from the tractor was transmitted from the PTO shaft of the tractor to the thresher and the thresher shaft got rotating, which resulted into initiation of threshing operation and the angular movement of pump simultaneously. The harvested wheat plants were fed manually through the inlet hopper of thresher which got threshed and the grains were separated from the crop and collected through an outlet in the gunny bags. The remaining crops were threshed into small particles called straw and blown away through a single specially designed straw outlet having two nozzles. The nozzles sprayed the urea solution over the straw coming out from this outlet and the straw got treated by wetting and settled down. Care was taken to confine all the straw into a closed boundary made up of gunny bags to avoid the losses during threshing due to blowing. The treated straw was then gathered in the form of a heap and covered it with commercially available polythene sheet for a reaction period of 21 days to complete the ammoniation process.

***Animal feeding*:** Sixteen *Murrah* buffaloes of mid-lactating stage (mean body weight: 490.0 ± 11.30 kg and milk yield: 5.55 ± 0.36 kg) were randomly distributed in untreated (UWS) and urea treated dietary groups (UTWS) with eight animals in each. Buffaloes of UWS were maintained on the diet consisting of untreated wheat straw (UWS) and concentrate mixture I while the animals of UTWS were fed urea treated straw and concentrate mixture II on iso-nitrogeneous basis for a period of 90 days (Table 1). Animals of both the groups were offered crude protein (CP) and total digestible nutrient (TDN) as per their requirement for maintenance and milk production (ICAR, 1985) during summer. Animals were offered wheat straw and concentrate mixture in separate troughs to individual animal once daily at 10.00 h for the entire experimental periods. Clean drinking water was provided to all the animals twice daily at11.00 and 16.00hrs. After 75 days of feeding, a digestion trial was conducted for 7 days following standard procedure. Total milk yield and milk composition was recorded for individual animals at fortnight interval.

***Analytical techniques*:** Feed and faeces samples were analyzed for CP, EE and total ash contents (AOAC, 1995) and fiber fractions (Van Soest *et al*., 1991). Milk fat, total solids (TSS) and milk protein were estimated by using the methods of Sastry *et al*. (1999) and milk urea N as per Conway (1957). Solid not fat (SNF) content of milk was calculated by substracting fat percentage from total solids. Blood samples were collected in heparinized test tubes 3 hours post feeding to study the various metabolites viz glucose (Somogyi 1945), urea (Rahmatullah and Boyde, 1980) and protein (Reinhold, 1953). The TDN values were converted to DE, ME and NE_L using the formula suggested by NRC 2001. Milk yield was adjusted to 6% fat corrected milk (FCM) yield, and solid corrected milk (SCM) was calculated by the equation of Tyrrell and Reid (1965) as follows: 6% FCM=.308 x total milk (kilograms) + 11.54x total fat (kilo grams)
SCM (kilograms)= 12.3F + 6.56SNF – 0.0752M, where F,SNF and M are fat, solid- not- fat, and milk (kg), respectively. Milk energy content was estimated following the formula given by MAFF (1975).

Statistical analysis: The data on intake, digestibility were analyzed using one way ANOVA. The data on milk yield and composition recorded at different fortnights were analysed in repeated measures ANOVA using SPSS ver.13.0.

Results and Discussion

Chemical composition of urea treated straw: The urea treatment of wheat straw during threshing increased the moisture content to around 28-32 percent and caused an intensive ammonia smell when stacks were open in summer. Moisture content of urea treated straw was sufficient to achieve the favourable rate of urea hydrolysis to ammonia (Dass, 2000). The CP content of urea treated wheat straw had increased from 3.64% to 9.02% due to retention of ammonia nitrogen. Yadete (2014) reported that urea treatment of wheat straw increases protein content from 3.2 to 6.0%. Similarly due to urea treatment there was an increase in the ash content from 9.01 to 10.51%. Mesfin and Ktaw (2010) recorded the increase in ash content in urea treated straw, since soluble nutrients like CP, nitrogen free extract (NFE), and soluble carbohydrates were dissolved and lost in solution. However, neutral detergent fiber content decreased by 6.69% in treated straw, and total carbohydrate content of treated straw was also reduced by 7.97% which might be due to solibilization of cell wall constituent particularly hemicellulose. A reduction in the cell wall content was also observed in urea treated wheat straw earlier (Abede *et al*., 2004).

Table 1. Ingredient (%) and chemical composition of Diet I (UWS based) and Diet II (UTWS based)

Ingredient		Diet I	Diet II					
Mustard seed cake		14	10					
Barley grain		10	10					
Maize grain		14.8	18.8					
Mineral mixture		1.2	1.2					
Wheat straw untreated		60	-					
Urea treated wheat straw		-	60					
Chemical composition (g kg^{-1} DM)								
Particulars	Ingredient	DM	OM	CP	NDF	ADF	EE	TCHO
Diet I	UWS	931.8	909.1	36.4	755.5	492.4	16.4	856.3
	Concentrate I	951.5	925.7	185.3	294.3	125.9	50.8	689.6
Diet II	UTWS	682.0	894.9	90.6	704.9	477.5	16.1	788.2
	Concentrate II	936.9	942.0	140.2	279.7	112.1	49.0	747.2

Table 2. Nutrient Intake and digestibility by Murrah buffaloes fed UWS and UTWS based rations

Particulars	UWS	UTWS	SEM	P value
Intake/day				
Straw (kg)	7.64[a]	8.46[b]	0.34	0.034
Concentrate (kg)	4.88[b]	3.98[a]	0.17	0.000
Total DM (kg)	12.52	12.44	0.60	0.893
DM (%body weight)	2.58	2.53	0.09	0.625
DM (g/kg W $^{0.75}$)	120.99	119.07	3.99	0.638
DCP (g/kg W $^{0.75}$)	6.95	7.33	0.21	0.095
NDF (kg)	7.10	7.02	0.39	0.830
ADF (kg)	4.34	4.47	0.25	0.825
OM (kg)	11.45	11.31	0.51	0.773
TDN (g/kg W $^{0.75}$)	73.19	73.27	3.49	0.968
ME (kcal/ kg W $^{0.75}$)	260.58	260.86	12.44	0.968
Digestibility coefficient (%)				
DM	61.28	63.51	1.52	0.165
OM	63.03	64.57	1.50	0.322
CP	59.97	57.85	1.22	0.097
NDF	48.91[a]	53.40[b]	1.96	0.000
ADF	46.46[a]	51.18[b]	2.16	0.046

[ab]Means on the same row with different superscript differ significantly (P<0.05)

Feed intake and utilization: Buffaloes had comparable dry matter intake (DMI) on untreated and urea treated diets (Table 2), however, roughage intake was significantly (P<0.05) higher in UTWS group than UWS group as reported earlier by Agrawal *et al*. (2014). The results of present study on DMI by the buffaloes corroborated the findings of Hassan *et al*. (2011) who observed no difference in DM intake when they fed the urea treated wheat straw fermented with cattle manure and molasses to buffaloes. The improvement in straw intake after urea treatment was well established and it depends on straw quality as well as treatment conditions (Sharma *et al*., 2004). Improvement in straw intake was attributed to relatively higher degradable straw fraction (hemicellulose) in UTWS due to breakdown of linkage between hemicellulose and lignin (Sarwar *et al*., 2004). Improved degradation of straw fractions coupled with gradual release of ammonia might have accelerated to degrade more feed by enhancing ruminal enzyme production per unit of time (Chumpawadee *et al*., 2006.) Another reason of enhanced straw intake by the buffaloes was due to softening of apparent structural stiffness or hardness of wheat straw. An improvement of straw intake by 10.63% in lactating buffaloes fed UTWS diet was observed by Sarwar *et al*. (2011). It was generally observed that forage intake drops significantly when animals were fed roughages with crude protein levels less than 7% (Chriyaa *et al*., 1997) which was the case with UWS group (3.64%) in the present study.

The nutrient intake (kg/day) in terms of digestible crude protein (DCP) and ME (Mcal/day) from composite diet was sufficient to meet the maintenance and milk production requirements of buffaloes in both the groups. The lack of difference in nutrient intakes in the present study might be because of approximately similar NDF and ADF intake by buffaloes in both the groups. Buffaloes had similar DM, OM and CP digestibility on both types of diets. The non significant difference in DM and CP digestibility in lactating *Murrah* buffaloes fed UWS and UTWS diet was probably because of the similar ruminal disappearance and digestion of urea treated straw and concentrates (Hassan *et al*., 2011). On the other hand, buffaloes had significantly (P< 0.05) higher NDF, ADF digestibility (Table 2) on UTWS diet than UWS diet. Higher NDF digestibility in lactating Murrah buffaloes fed UTWS diets compared with UWS diet might be because of better ruminal NH_3 concentration. Ammonia might have cleaved linkages between lignin and cellulose or lignin and

hemicellulose and thus increased extent and rate of NDF digestion due to cleavage of ester bonds and acetyl groups by chemical treatment (Buettner *et al*., 1982). Moreover, higher NDF digestibility by *Murrah* buffaloes fed UTWS diets was probably due to more optimum cellulolytic microbial activity in higher ruminal pH. Improvement in NDF digestion of low quality urea treated roughages was also documented earlier (Nisa *et al*., 2006).

Table 3. Milk yield, milk and blood composition of Murrah buffaloes fed urea treated straw

Parameters	UWS	UTWS	SEM	P value
Milk yield (kg/d)	5.40	5.27	0.40	0.755
6% FCM yield (kg/d)	6.38	6.14	0.64	0.709
SCM yield (kg/d)	8.11	7.80	0.77	0.698
Milk composition (%)				
Protein	4.25	4.17	0.06	0.234
Fat	7.58	7.32	0.43	0.565
SNF	9.87	9.77	0.14	0.517
Total solid	17.59	17.20	0.48	0.436
Urea (mg/dl)	16.18[a]	24.14[b]	0.74	0.000
Milk energy (MJ/kg)	4.72	4.60	0.18	0.515
Blood metabolites				
Urea (mg/dl)	23.04	28.21	0.36	0.182
Glucose (mg/dl)	82.12	86.30	0.46	0.476
Total protein (g/dl)	6.72	6.62	0.52	0.438
Intake/kg SCM				
DM	1.56	1.66	0.15	0.514
DCP	0.09	0.10	0.01	0.235
TDN	0.95	1.01	0.09	0.459
ME (M cal)	3.36	3.60	0.31	0.456

[ab]Means on the same row with different superscript differ significantly (P<0.05)

Milk yield and composition: Milk yield (6% FCM) by buffaloes fed UWS and UTWS diets was similar (Table 3). The differences in percent milk fat, CP, TS and SNF were also non-significant (P<0.05). Digestible crude protein and metabolizable energy efficiency for 1 kg SCM production were identical for animals on both dietary regimes. The non-significant difference in milk yield (6% FCM) in buffaloes fed two different diets might be due to comparable digestibility of urea treated straw to that of concentrate, which did not cause any significant change in 6% FCM yield when substituted for concentrates in the UTWS diets of lactating *Murrah* buffaloes. Arave *et al*. (1990) also recorded no effect on FCM yield when lactating cows were fed poultry excreta up to 17% in the diet.

Feeding of UTWS diet did not affect the milk fat, protein and total solids content of milk. However, Sanh and Wiktorsson (2002) in feeding of urea treated rice straw to crossbred lactating cows reported an increase in fat concentration and no changes on total solid content of milk. The BUN and MUN values observed in the buffaloes fed UTWS diets were within the normal physiological range, but higher than earlier report (Broderick *et al*., 1993) for cattle. These differences in values for BUN and MUN might be due to species difference. They reported higher urea concentrations in blood and milk in lactating cows when fed urea treated corn silage compared with control. However, Mojumdar *et al*. (2003) reported higher BUN and MUN values in crossbred cows when concentrate was replaced upto 35% with urea treated straw in the diet. During the experiment, intake of DM, DCP and ME did not vary significantly on both types of diets. Hence, increased urea values likely due to the fact that CP fraction of treated straw of UTWS diet was more degradable than UWS diet.

Cost of milk production: On Feeding UTWS diet, the cost of milk production (Table 4) was lower (Rs 94.55/ day) than with UWS diet (Rs 110.80 /day). The changes in costs and returns of a milking buffalo feeding system with urea treated straw in comparison to untreated straw based ration were examined on a 90 days lactation trial. The additional costs involved were the cost of urea treatment of straw (Rs 26/qt of wheat straw). Based on market milk price of Rs 30/kg, buffaloes fed UTWS diet had significantly (P<0.05) higher net return (Rs 11.63 /kg milk/day) compared to UWS diet (Rs 9.23/kg milk/day). The economic advantage of feeding urea treated straw over untreated straw to milking animals was reported by different workers earlier (Sharma *et al*., 2004; Chemjong, 1991). A net return of Rs 4 to 10 (in Nepalese currency) was reported in lactating buffaloes fed urea treated straw based diet (Chemjong, 1991). Prasad *et al*. (1998) reported that the cost of feeding per kg FCM yield was lower with rations containing urea treated rice straw. In the present study, the cost per kg FCM (6%) yield with UWS diet was higher (Rs 13.64) than UTWS diet (Rs 12.10).

Conclusion

It was concluded that threshers fitted with attachment device for urea treatment offers the option for resource poor farmers to get their straw treated during threshing only at very nominal cost (only the urea) without any additional labour and the cumbersome arrangement required in conventional urea treatment method. Moreover, the urea treatment of straw during threshing not only saves the amount of expensive protein supplement incorporated into the concentrate mixture, but also increases straw intake leading to better use of straw offered and thereby better economic return.

Table 4. Cost-profit analysis for the experiment

Cost of items	Cost (Rs.)				
Wheat straw (UWS)	2.50/kg				
Urea treated wheat straw (UTWS)	2.76/kg				
Concentrate I	18.80/kg				
Concentrate II	17.90/kg				
Type of feed	**Cost of production (Rs)**	**Average milk yield/d (kg)**	**Price of milk/kg (Rs)**	**Gross return /Buffalo/d (Rs)**	**Net return /kg milk (Rs)**
UWS diet	110.80	5.40	30.00	161.97	9.23[a]
UTWS diet	94.55	5.27	30.00	158.14	11.63[b]

[ab]Means on the same row with different superscript differ significantly (P<0.05)

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