Nutritional Evaluation of Lentil (*Lens culinaris*) Straw and Urea Treated Wheat Straw in Goats and Lactating Buffaloes

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ABSTRACT : The nutritive value of lentil straw *(Lens culinaris)* relative to 4% urea treated wheat straw (w/w) was assessed in adult bucks and milking buffaloes on-station and on-farm, respectively. A digestion-cum-nitrogen balance experiment was conducted with three bucks (24.35 kg) fed *ad libitum* lentil straw (LS), urea treated wheat straw (UTS) and a 1:1 (w/w DM basis) mixture of LS and UTS (LS:UTS) in a 3×3 Latin square design. Though daily dry matter intake (g kg $W^{0.75}$ or % LW) of bucks fed LS and UTS did not differ significantly, that of LS:UTS was significantly ($p<0.05$) low. Similarly, digestibility of nutrients (DM, OM and CP) and nitrogen balance (g/day) did not differ significantly for bucks given LS or UTS although a significant positive improvement was evident in these parameters for LS:UTS. The digestibility of fibre fractions (NDF and ADF) was significantly ($p<0.05$) lower in LS as compared to UTS or LS:UTS. Except for the significantly ($p<0.05$) lower intake of DCP (g kg$W^{0.75}$), the bucks fed LS had statistically similar nutrient intake as compared to UTS. Feeding of LS:UTS resulted in significantly higher nutrient (DCP, TDN) intake by bucks. The important blood-biochemical parameters (haemoglobin,packed cell volume, glucose, urea nitrogen, total protein) and activity of serum enzymes (alanine aminotransferase and aspartate aminotransferase) did not differ significantly in goats irrespective of dietary treatment. In the on-farm study, eighteen multiparous milking buffaloes were randomly assigned into three equal groups to assess the relative effect of feeding untreated wheat straw (WS), UTS and LS:UTS *ad libitum* as basal feed with a supplement. The study continued for 3 months and revealed that daily dry matter intake and average milk production (liters/day) by buffaloes offered LS:UTS and UTS was statistically similar but it was significantly higher compare to WS. However, milk composition did not differ significantly among the dietary treatments. It may be concluded that the nutritive value of lentil straw appeared to be no different to UTS, however, a positive synergistic effect was evident by feeding a mixture of LS and UTS on performance of goats and lactating buffaloes. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 11 : 1529-1534)***

Key Words : Goats, Lactating Buffaloes, Lentil Straw, Nutritional Evaluation, Urea Treated Wheat Straw, Milk Yield

INTRODUCTION

Nutrition remains by far the most critical constraint to increased animal productivity and more efficient performance across the developing countries (ILRI, 1995) because small holder livestock production systems are largely based on fibrous crop residues. The major limitations with crop residues include their bulkiness and poor nutritive value. Urea-ammoniation treatment of cereal straw is a technically effective and feasible technology to improve the nutritive value of fibrous crop residues (Dolberg, 1992), though its application in the field has been very limited in India. Various factors have contributed to the absence of impact, most notably the lack of on-farm trials and demonstration of satisfactory cost: benefit ratio of using urea treated straw during the production cycle of the animals. There is evidence that supplementation with other feeds that provide additional proteins, energy and minerals may improve the utilization of urea treated crop residues (Singh et al., 1993). However, the choice of supplements by resource poor farmers is usually driven by two factors-availability and cost. More researches are required in on-farm feeding trials involving the physiological and other effects of cheap supplements.

Lentil (*Lens culinaris*) is increasingly being grown in large areas of Upper Gangetic Plains of India as an important pulse crop. Lentil straw (LS) comes from the traditional threshing process and includes broken branches, pod walls and leaflets. Despite higher concentration of crude protein and digestible energy than cereal straws (Hadjipanayiotou, 1997), farmers usually prefer to burn LS or leave it in the field after threshing of the crop. The proposed experiment was based on the hypothesis that intake and digestibility of nutrients may be higher in the mixture of LS and UTS than the sum of the parts due to positive associative effect by improved synchronization of readily available nitrogen in UTS and soluble carbohydrates and minerals present in lentil straw. Subsequently, an on-farm trial was undertaken to demonstrate potential efficacy of LS as a partial substitute of UTS for milk production by buffaloes within the prevalent feeding systems followed by the farmers. There is limited information available on the comparative nutritive value of LS and urea treated wheat straw (UTS). The objective of this study was to evaluate nutritive value of LS and UTS, as compared with a mixture (1:1 w/w) of LS and UTS in bucks.

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Received October 15, 2003; Accepted June 4, 2004

MATERIALS AND METHODS

On-station experiment

Animals, experimental design and diet : The experiment was conducted during November 2001 to February 2002 at the Indian Veterinary Research Institute. Three local non-descript bucks, about 3 years old with a mean live weight of 24.35 kg were used for the experiment. The bucks were assigned to three dietary treatments viz. LS, UTS and a 1:1 mixture (w/w on dry matter basis) of LS and UTS (LS:UTS) in a 3×3 latin square design (three treatments and three periods). Air dried wheat straw was treated at the rate of 50 liters of a 8% urea solution (80 g urea per liter water) per 100 kg of straw. Urea treated straw was stacked, compressed manually and covered with empty plastic urea sacks for adequate fermentation for a minimum period of one week before feeding it to bucks. The bucks were given a vitamin and mineral supplement (Supplevite-M, Sarabhai Zydus, India) to meet their daily requirements for vitamin A and minerals. The feeding experiment was carried out for 42 days duration including the first 35 days for adaptation and subsequent 7 days collection and measurement period in metabolic stalls during each period. The animals were offered water free choice and weighed at fortnightly intervals in the morning before offering the feed. The daily feed intakes and the faecal and urinary outputs from individual bucks were measured. Suitable subsamples of faeces and urine were collected daily, pooled by buck and preserved with 20% (v/v) sulphuric acid for nitrogen estimation. Another sub sample of the daily faecal output was dried at 80°C for 24 h in a forced-draft oven for dry matter estimation. Samples of dried feeds, refusals and faeces were pooled over the seven days and preserved in airtight polythene bags for further analysis.

Blood was collected by jugular vein puncture at the end of each metabolism trial and the harvested serum was preserved at -20°C until further analysis. Another 2 ml blood sample was collected in tubes containing ethylene diamine tetraacetate at 1 mg/ml blood, for haematological parameters.

Chemical and statistical analyses : Samples of feeds, residues and faeces were milled to pass through a 1 mm sieve and analysed for their proximate constituents (DM, CP, EE and Ash) along with the milk (Total solids, CP, Fat, solids not fat (SNF) and Ash) (AOAC, 1995). The fibre fractions, neutral detergent fibre (NDF) and acid detergent fibre (ADF), were estimated according to the methods of Goering and Van Soest (1970). Haemoglobin and packed cell volume (PCV) were estimated in whole blood immediately after blood collection by acid haematin method (Benjamin, 1985) and Wintrobe's tube (Hawk, 1965), respectively. Serum glucose concentration was determined colorimetrically (Hultmann, 1959). The serum protein and albumin (A) content were measured as per Wotton (1964) and Doumas et al. (1971), respectively. The activity of serum enzymes, alanine aminotransferase (ALT) and aspartate aminotransferase (AST; Reitman and Frankel 1957) and serum urea (Rahmatulla and Boyde, 1980) were estimated as per standard colorimetric methods with the help of a spectrophotometer (Spectronic 20, Spectronic Instruments, USA). Data were subjected to analysis of variance and statistical significance between treatment means ignoring the period effect (Snedecor and Cochran, 1989).

On farm experiment

Experimental site : The location was chosen for the on-farm investigation, the Bareilly district of Uttar Pradesh province, was located at 170 m above sea level (28°22' latitude north and 79°24' longitude east) in the Northern upper Gangetic Plain of India, having an annual rainfall of 900-1,200 mm. It is the region of the deepest soil in India, with hardly any variation in relief. This constitutes the wheat and the rice bowls of India and is fertile and suitable for growing various types of subtropical crops. Wheat and rice being the main cultivated crops, cereal straws form the basal diet of ruminants in the area. Milk production in the area is characterized by low yielding non-descript buffaloes and cows, small producers with little land holdings, use of crop residues with or without costly concentrates as feed supplement, and scarce land for forage production.

Experimental procedure : In May 2002, eighteen milking buffaloes belonging to sixteen farmers were chosen for the study in the village Makrandpur/Kalapur, District Bareilly. The selected buffaloes (25-40 days post-calving) were in their first to third lactation, with a production of

Table 1. Chemical composition of experimental diets (%DM)

Attributes	On-station			On-farm	
	LS	UTS	LS:UTS	WS	FFC
Dry matter	92.21±0.25*	72.5±1.51	83.50±0.91	91.50±0.21	92.00±0.59
Crude protein	6.45±0.20	8.50±0.32	7.40±0.29	4.10±0.23	16.10±1.15
Ether extract	1.55±0.11	0.91±0.12	1.30±0.10	1.15±0.17	11.08±0.35
Total ash	7.47±0.23	6.80±0.25	6.37±0.20	7.10±0.21	12.80±0.45
Neutral detergent fibre	64.14±0.61	82.10±1.12	75.26±1.11	83.27±1.24	36.51±0.32
Acid detergent fibre	38.12±0.48	58.33±0.89	48.19±0.82	57.01±0.75	14.87±0.29

LS: Lentil straw. WS: wheat straw. Urea treated wheat straw. LS:UTS: 50:50 mixture of LS and UTS FFC: Farmers' formulated concentrate.

* Mean±SE.

Table 2. Nutrient utilization and plane of nutrition of bucks fed Lentil straw (LS), urea treated straw (UTS) or a 50:50 mixture of LS and UTS (LS:UTS)

Attributes	Treatments			SEM
	LS	UTS	LS:UTS	
Dry-matter intake				
g kg $W^{0.75}$	59.20^{a}	63.03^{ab}	73.80^{b}	3.04
% live weight	2.63^{a}	2.85^{ab}	3.39^{b}	0.15
Digestibility coefficient (%)				
Dry-matter	46.35^{a}	50.04^{a}	53.94^{b}	1.31
Organic matter	47.22^{a}	54.63^{ab}	58.09^{b}	1.70
Crude protein	47.13^{a}	52.86^{ab}	54.48^{b}	1.39
Ether extract	50.62	47.66	47.99	2.03
Neutral detergent fibre	42.14^{a}	53.13^{b}	57.60^{b}	2.49
Acid detergent fibre	34.68^{a}	48.43^{b}	47.63^{b}	2.47
Nutrient density (%)				
Digestible crude protein	3.16^{a}	4.50^{c}	4.04^{b}	0.21
Total digestible nutrients*	45.88^{a}	53.76^{b}	57.12^{b}	1.75
Nutrient intake (g kg $W^{0.75}$)				
Digestible crude protein	1.78^{a}	2.83^{b}	2.98^{b}	0.22
Digestible dry-matter	27.47^{a}	31.57^{a}	39.89^{b}	2.38
Digestible organic matter	25.87^{a}	31.54^{a}	40.18^{b}	2.38
Total digestible nutrients	27.17^{a}	33.78^{a}	42.19^{b}	2.50

^{a,b} Means with different superscripts in a row differ ($p<0.05$)

* TDN calculated from digestible organic matter (DOM).1.0 kg DOM=1.05 TDN (NRC, 1981).

4.0-7.0 kg of milk per day. The experiment was conducted over a period of 3 months. The buffaloes were randomly divided into three equal groups and given free choice untreated wheat straw (WS), UTS and a mixture (1:1) of LS:UTS as basal roughage, respectively. A Farmers' formulated supplement (FFS; Parts/100:*Soybean meal/Mustard cake 10-12; rice polish 88-90*) was fed to each buffalo at 0.5 kg for each kg of milk produced in consultation with the farmers. Although, LS as a sole basal feed was tested in the on-station experiment, a lower level was chosen i.e. replacing only 50% of the UTS, inview of the participating farmers' perception of LS quality and its limited availability with them. Mineral mixture and salt (30 g each) was provided to all the buffaloes irrespective of dietary treatment to avoid a compensatory intake effect of UTS or LS:UTS on mineral deficient animals.

The researchers, in consultation with the farmers twice a week measured feed intake of each buffalo, which were averaged to calculate mean daily feed intake. The participating farmers kept daily records of milk yield (two milking/day). Milk samples were drawn at fortnightly intervals and brought to the laboratory for further analysis. The data generated were statistically analysed and treatment means for the three treatments were ranked using Duncan's multiple range test (Snedecor and Cochran, 1989).

RESULT AND DISCUSSION

On-station experiment

Intake and nutrient digestibility : The chemical composition of LS and UTS was similar to values reported earlier (Erskine et al., 1990; Hadad and Husein, 2001; Lamba et al., 2002). The level of crude protein (CP) and cell wall fractions (NDF, ADF) were relatively lower in LS and the composition of LS:UTS reflected the mean of the two feed-stuffs.

The dry-matter intake (g/kg $W^{0.75}$ or % LW) intake of LS was not different from that of UTS, however, the intake of LS:UTS was greater than that of LS. The DMI ranged from 59 to 74g/kg $W^{0.75}$ and it clearly indicates that bucks had adequate intake for maintenance (Kearl, 1982) and all the three diets were palatable and non-repugnant (Table 2). Crude protein content of experimental diets approached levels of 7-8% on an average, which are normally considered the minimum dietary requirement for proper intake and digestive activity of rumen microorganisms (Erskine et al., 1990; Chriyaa et al., 1997). The apparent digestibility of nutrients (DM, OM, and CP) did not differ significantly ($p<0.05$) for bucks given LS or UTS, although a significant positive improvement was evident in these parameters for LS:UTS as compared to LS. However, digestibility of cell wall fractions (NDF, ADF) was significantly ($p<0.05$) lower for LS as compared to UTS or LS:UTS. It is understandable because urea treatment of cereal straws improves rate and extent of cell wall degradation due to hydrolysis of alkali labile lignocellulosic bonds in straw by released ammonia from urea during fermentation, thereby increasing their efficient utilization by rumen micro-organisms (Lamba et al., 2002). Results further suggest that intake and digestibility of LS: UTS mixture was not much different to UTS alone but was significantly better than LS, probably due to positive

Table 3. Nitrogen (N) balance of bucks fed Lentil straw (LS), urea treated straw (UTS) or a 50:50 mixture of LS and UTS (LS:UTS)

Attributes	Treatments			SEM
	LS	UTS	LS:UTS	
N-intake (g d^{-1})	6.95^a	9.26^b	9.03^b	0.42
N-output (g d^{-1})				
Faecal	3.68	4.34	4.11	0.13
Urine	1.57^a	2.60^b	2.16^{ab}	0.18
Total	5.25^a	6.93^b	6.10^{ab}	0.31
N-balance (g d^{-1})	1.70^a	2.34^{ab}	2.92^b	0.21
N- retention				
as % of intake	24.46	25.71	32.86	1.78
as % of absorbed	47.50	47.55	59.86	2.96

a, b Means with different superscripts in a row differ ($p<0.05$).

Table 4. Blood-biochemical profile of bucks fed Lentil straw (LS), urea treated straw (UTS) or a 50:50 mixture of LS and UTS (LS:UTS)

Attributes	Treatments			SEM
	LS	UTS	LS:UTS	
Haemoglobin (g dl^{-1})	10.83	11.50	10.33	0.35
Packed cell volume (%)	33.33	36.33	34.33	1.06
Glucose (mg dl^{-1})	44.85	45.22	42.60	1.76
Urea (mg dl^{-1})	35.56^a	47.22^b	39.55^a	2.00
Total protein (g dl^{-1})	6.41	6.25	6.89	0.15
AST* (IUL^{-1})	60.60	63.66	59.49	2.45
ALT** (IUL^{-1})	28.28	25.35	30.27	2.10

a, b Means with different superscripts in a row differ ($p<0.05$).
* AST: Aspartate aminotransferase.
** ALT: Alanine aminotransferase.

associative effect by improved synchronization of readily available nitrogen in UTS and soluble carbohydrates and minerals from lentil straw for stimulated microbial activity (Burroughs et al., 1950; Hunt et al., 1954). The factors responsible for variable effects of feeds on intake and digestibility may include difference in their rate of passage of digesta, packing density, dietary concentration of ruminally degradable protein, availability of branched chain fatty acids, rapidly fermentable β-glucans and some micro-minerals and vitamins, especially in leguminous forages (Goodchild and McMeniman, 1994; Khandaker et al., 1998; Sharma et al., 1998).

Plane of nutrition

Total digestible nutrients (TDN) was significantly ($p<0.05$) lower in LS relative to comparable values of UTS and LS: UTS. DCP concentration was associated to relative concentration of CP in test feeds and it was significantly ($p<0.05$) higher in UTS followed by LS: UTS and LS. Similarly, DCP intake (g/kg $W^{0.75}$) by animals on LS was significantly ($p<0.05$) lower as compared to values observed for UTS and LS:UTS. However, intake (g/kg $W^{0.75}$) of digestible dry matter (DDM), digestible organic matter (DOM) and TDN was comparable by bucks fed either LS or UTS but it was significantly lower relative to bucks on LS:UTS. Animal performance usually depends on intake of digestible and metabolizable energy (Mertens, 1994); any increase in energy intake will ultimately improve production efficiency if protein is not limiting. In this study, though intake of TDN (28.0 g) was sufficient to meet the stipulated recommended maintenance allowance of bucks irrespective of dietary treatments (NRC, 1981; Kearl, 1982). DCP intake of bucks on LS was not sufficient to fulfill their recommended requirement (2.8 g) for maintenance (NRC, 1981; Kearl, 1982). It is apparent from the results that mixing of LS:UTS contributed to the increased intake of DOM and TDN but did not increase DCP.

Nitrogen balance

The intake of nitrogen (g/d) was significantly ($p<0.05$) lower in bucks fed LS compared to animals fed UTS and LS: UTS (Table 3) and reflective of relative CP values and intake of experimental feeds. There was no effect of diet on faecal-N excretion (g/d), but the urinary-nitrogen excretion (g/d) was significantly ($p<0.05$) lower in LS than in UTS. However, urinary-nitrogen excretion by bucks fed LS:UTS was not different to the other two groups. Similarly, total-nitrogen excretion (g/d) by bucks was significantly ($p<0.05$) lower in LS compared to UTS, although total N-excretion by bucks given LS:UTS did not differ significantly from the other treatments (Table 3). Nevertheless, dietary treatment did not influence efficiency of nitrogen utilization by bucks as evidenced by nearly similar nitrogen-retention as % of intake and as % of absorbed nitrogen recorded for the three groups. Although nitrogen- balance (g/d) was positive in all the bucks, it was significantly ($p<0.05$) lower in LS relative to LS:UTS. However, nitrogen- balance in UTS was not different ($p>0.05$) to other treatments. Higher N-balance in LS: UTS could be attributed to better synchronization of readily fermentable carbohydrates and nitrogen present in LS and UTS, respectively that results in net positive associative effects (Burroughs et al., 1950; Hunt et al., 1954; Hadad and Husein, 2001).

Blood-biochemical parameters

The blood-biochemical profile of bucks on different treatments is summarized in Table 4. The levels of haemoglobin (g dl^{-1}), packed cell volume (%), glucose (mg dl^{-1}), total serum protein (g dl^{-1}), ALT (IUL^{-1}), AST (IUL^{-1}) were not different among treatments ($p<0.05$) and were with in the reported normal physiological range (Benjamin, 1985; Kaneko, 1997; Anbarasu, 2002; Rastogi et al., 2003). Serum urea level (mg dl^{-1}) was significantly ($p<0.05$) higher on UTS in comparison to analogous levels observed in bucks fed LS and LS: UTS. The higher serum urea level in UTS may be due to higher intake of NPN by bucks on UTS diet (Naik, 2002).

Table 5. Intake and milk yield by buffaloes fed untreated wheat straw (WS), Urea treated wheat straw (UTS) or a 50:50 mixture of lentil straw and UTS (LS:UTS) as basal roughage

Attributes	Treatments			SEM
	WS	UTS	LS:UTS	
Body weight of buffaloes, kg				
Initial	492.5	493.0	492.0	6.75
Final	488.0	490.5	495.5	6.81
Intake, kg d $^{-1}$				
Dry matter	10.67 ^{a}	13.09 ^{b}	14.04 ^{b}	0.61
Roughage	8.67 ^{a}	10.87 ^{b}	11.79 ^{b}	0.53
Concentrate	2.01	2.22	2.25	0.22
Dry matter intake				
kg $W^{0.75}$	102.45 ^{a}	125.31 ^{b}	134.20 ^{b}	5.51
% live weight	2.18 ^{a}	2.66 ^{b}	2.85 ^{b}	0.18
Milk yield, kg d $^{-1}$				
Initial	4.76	4.70	4.85	0.21
Final	3.80 ^{a}	4.56 ^{b}	5.35 ^{c}	0.19
Average	4.20 ^{a}	4.73 ^{ab}	5.17 ^{b}	0.22
Total (90 d)	377.60 ^{a}	425.72 ^{ab}	465.30 ^{b}	19.78
Milk composition				
Total solids	17.36	17.24	17.32	0.73
Solids not fat	10.35	9.94	10.05	0.28
Crude protein	3.87	3.60	3.85	0.19
Fat	7.01	7.30	7.25	0.35
Ash	0.76	0.75	0.80	0.019

^{a,b} Means with different superscripts in a row differ ($p<0.05$).

On-farm experiment : Feed intake, live weight changes and milk production of buffaloes recorded during the feeding trial of 3 months are given in Table 5. Total dry-matter intake (kg/d or kg $W^{0.75}$ or % LW) of lactating buffaloes eating LS:UTS and UTS, was significantly ($p<0.05$) higher than intake observed in animals given WS. Intake (kg/d) of concentrate by buffaloes was not different ($p>0.05$) among different treatments. The higher DMI by buffaloes fed LS:UTS and UTS and might be due to the efficient nutrient utilization of UTS by rumen microbes with urea treatment of wheat straw and presence of relatively higher percentage of digestible carbohydrates usually found in legumes (Sharma et al., 1998; Narayan Dutta et al., 1999; Anbarasu et al., 2002). Milk yield at the end of experimental period was significantly higher ($p>0.05$) in buffaloes given LS:UTS, followed by UTS and lowest in WS. Average milk yield (kg/d) and total milk produced during 90 day trial was significantly ($p>0.05$) higher on LS:UTS compared to WS, however, these parameters recorded for buffaloes fed UTS were not different to other groups. The total solids, SNF, CP, fat and ash concentrations in milk were not different among treatments. The better performance of buffaloes either on UTS or LS:UTS was consistent with the observations recorded in bucks in the on-station experiment indicating higher intake and utilization of nutrients by animals as compared to their counterparts fed only untreated wheat straw. Cell wall carbohydrates are the major source of energy for rumen microbes on a straw diet like WS. Urea treatment, apart from being a source of nitrogen for microbial synthesis, also provides additional energy by weakening of the lignocellulose bonds. An increase in milk yield ranging from 0.5-1.5 liters/animal/day was reported when feeding UTS to animals (Birthal and Parthasarthy, 2002), which is comparable with observations in this on-farm trial. The similar quality of milk irrespective of dietary treatments is in conformity with the report of Lamba et al. (2002) who reported unchanged milk quality by buffaloes fed ammoniated straw as a basal diet. The initial and final live body weights of buffaloes did not differ significantly irrespective of dietary treatments.

In the on-farm experiment, an attempt was made to motivate farmers to use lentil straw as a substitute for UTS, within their resource constraints. Therefore, only LS:UTS combination was used in this trial. This being the field study, the feeding regime commonly practiced by the farmers was followed as far as possible. Accordingly, the composition of the supplement (FFS) and the participating farmers' apprehensions attached to the use of LS were also taken into account. All the participating farmers reported good palatability of LS:UTS and UTS relative to WS and appreciated the response of buffaloes in terms of improvement in the milk yield during the study.

The study demonstrates that lentil straw is closer in its nutritive value to 4% urea treated wheat straw and its utilization can be improved by feeding in a mixture (1:1) lentil straw and 4% urea treated wheat straw. Mixing of LS and UTS improves intake, nutrient utilization and consequently milk production of animals with out any adverse effect on health or milk quality possibly due to a positive synergetic effect by synchronization of readily available nitrogen in UTS and soluble carbohydrates and minerals from lentil straw.

ACKNOWLEDGEMENT

This study was financially supported by funds provided by Indian Council of Agricultural Research (AP-Cessfund), NewDelhi, India.

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