RELEVANCE OF THE RDP/UDP SYSTEM FOR FEEDING OF RUMINANTS IN THE TROPICS WITH EMPHASIS ON STRAW BASED DIETS

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SUMMARY

The system of protein evaluation based on RDP/UDP values as proposed by ARC and later adopted by NRC, considers the microbial needs for rumen degradable protein (RDP) and the host's need (at the tissue level) for absorbed amino acids derived from microbial protein and the undegraded dietary protein which escapes rumen fermentation. Microbial protein synthesised in the rumen is a function of energy made available as ATP from the fermentation of dietary carbohydrates. Insufficient extraction of energy by microbes from cell wall rich crop residues results in limited energy availability for rumen microbial growth. The N degradability of straw in the rumen is reported to be 50-60%, but the inherently low N values of straw makes the RDN availability also a limitation. From available literature, it was calculated that one kg of wheat straw on DM basis could supply 3.1 g of RDN, 2.5 g of UDN and 6.1 MJ of ME. The corresponding values for urea treated straw worked out as 8.75 g of RDN, 3.75 g of UDN and 7.6 MJ of ME/kg DM. Untreated straw fed as a sole diet cannot meet RDN and ME requirements for maintenance of a 200 kg heifer or a 400 kg lactating animal. Feeding of urea treated straw as a sole diet can provide extra nutrients (RDN, ME) for 100-150 g of live wt gain/day to a 200 kg calf, or can provide extra nutrients for yielding 2-3 kg of milk/day from a 400 kg cow. For such a cow, supplementation of untreated straw with 4 kg of concentrate could provide sufficient RDN and ME to yield 5-6 kg of milk/day, whereas just one kg of concentrate is needed along with urea treated straw to achieve the same level of performance. Supplementation with 3 kg concentrate along with urea treated straw can supply sufficient RDN and UDN but ME for producing 10 kg of milk/day. Feeding of proteins of low degradability may supply insufficient protein and energy for achieving higher yields.

INTRODUCTION

The unique feature of ruminants is that they have two types of nutrient requirements; a) to satisfy the needs of the rumen microbes, b) to satisfy the needs of the animal tissues. Satisfying the needs of the microbes helps to satisfy the needs of the host animal, because the microbial protein produced in the rumen makes a large contribution to the protein supplied to organs and tissues. In the qualitative sense, the two

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requirements differ, in that the rumen microbes can be satisfied with ammonia as a source of N, while organs and tissues need amino acids. Awareness of these differences has led to the development of protein evaluation systems, based on the concept of (true) protein absorbed from the small intestines, elaborated in this workshop by Sampath *et al.* (1993).

Both the U.K. (ARC, 1980, 1984) and the US (NRC, 1982) have developed systems based on Rumen Degradable Protein (RDP)/Undegraded Dietary Protein (UDP) values in feeds and their requirements by animals. These systems recognise that the microbes in the rumen need RDP and the host animal uses at the tissue level the absorbed amino acids that are derived both from microbial protein and UDP. The conditions of the countries where the UDP/RDP were developed are in sharp contrast to the conditions existing in tropical regions but the number of countries in which systems based on CP or DCP are replaced by such new systems is increasing. This paper evaluates the relevance of such a system to India and other tropical countries, especially for diets containing large amounts of straw.

EFFICIENCY OF MICROBIAL GROWTH ON STRAW DIETS

Amino acid requirement at the tissue level of the host ruminant is primarily met through microbial protein synthesized in the rumen. Microbial growth (i.e. protein synthesis) in the rumen depends on:
- the supply of nitrogen from NH_3 as well as preformed amino acids,
- the supply of rumen digestible energy, carbon sources for amino acid synthesis,
- phosphorous and sulphur sources.

The efficiency of microbial synthesis is related to the amount of energy which is liberated as ATP during the fermentation of carbohydrates in the rumen to VFAs. Several workers have calculated the microbial N yield/kg OM apparently digested in the rumen (DOMR) and the mean value from 262 diets came to 32 g of microbial N/kg DOMR (Harrison and McAllen, 1980). ARC (1984) has adopted the Figure of 30 g N/kg DOMR to compute the RDN requirement for ruminants.

The major source of energy for rumen microbes on a straw diet is provided by cell wall carbohydrates. The production of microbial protein is therefore related to cell wall digestibility, if other factors for microbial growth are not limiting (Hvelplund, 1989). The first limiting factor for ruminant production in the tropics is frequently the insufficient extraction of energy as VFA and ATP by the microbes from cell wall rich crop residues. Such fibrous feeds are digested only slowly in the rumen, and therefore microbial growth will be slower, also because a larger proportion of the energy extracted from the substrate is required to maintain the microbes, resulting in the reduction in microbial cell yield per unit of VFA produced (Egan, 1988). This limitation can be overcome by the careful supplementation with easily fermentable carbohydrates like sugars and starch. However, when straws are supplemented with large amounts of rapidly fermentable carbohydrate components, the result is decreased fibre digestion, through the depression of ruminal pH (Mould *et al.*, 1983/84). Also, besides energy, the rumen microbes require rumen degradable N. Most cellulolytic bacteria can incorporate non protein nitrogen (NPN) via NH_3 into cell protein (Durand, 1989).

DEGRADABILITY OF STRAW N IN RUMEN

Crude protein content in straws is generally low (about 35 g CP/Kg DM), but varies considerably between varieties (Walli *et al.*, 1988, 1990; Prasad *et al.*, 1993). The rumen availability of N from cell wall rich low N crop residues is generally considered to be quite low, as most of the N is associated with cell walls and availability then depends upon the degradability of cell walls in the rumen.
The degradation of protein associated with cell walls, as in crop residues, is difficult to measure, due to the microbial contamination of feed residues left in the bags after incubation in rumen (Varvikko and Lindberg, 1985; Negi *et al.*, 1988). To avoid the contamination effect due to microbes, Kristensen *et al.* (1982) used N^{15} labelled straw to show an effective degradability of 61% for protein in untreated straw, at a passage rate of 5%/hour. Using N free cellulosic material as a control to make correction for microbial N contamination, Negi *et al.* (1988) reported 52.5% and 37% effective degradability for total N in wheat and rice straw respectively, at an outflow rate of 2.5%/hour. These results are in contrast with the general assumption that in rumen availability of N from cell wall rich and low N crop residues is low.

Concerning the form of nitrogen present in straws, Hvelplund (1989) reported that in straws a substantial amount of N is present as protein and amino acids. Of the total N present in barley straw, amino acid N contributes 50.6%. Oosting *et al.* (1990) reported that 51.5% of the total N in paddy straw is present as neutral detergent insoluble N (NDIN) with a true digestibility of 54% for this fraction (Table 1). From the above discussion it appears that the N availability to microbes from a straw diet may not be adequate for microbial growth. Addition of RDN to such diets may prove beneficial to the microbes and consequently to the host animal.

Urea/ammonia treatment not only increases the fibre digestion of straw but also its N content. Singh and Negi (1985) reported higher ADIN (Acid Detergent Insoluble N) for treated straw than for untreated straw.

RELEVANCE OF SUPPLEMENTING A DIET WITH UDP AND ITS AVAILABILITY FROM STRAW

Beneficial aspects of feeding protein of low degradability to ruminants

In ruminants, the microbial protein synthesized in the rumen is the major protein source utilized for body functions. However, higher growth rates and milk production levels, require higher protein : energy ratios then usually provided from microbial growth alone. Supplementation with undegradable dietary protein may enhance growth rate and milk production, especially under conditions of higher levels of production. Egan (1986) explained that the enhanced growth or milk production is mediated by:

- dietary protein intact or as peptide delivered to the lower tract can improve the amino acid availability for lean tissue,
- slow degradation of proteins can result in a more constant N supply to the rumen which may improve the supply of NH_3 and possibly peptides for the growth and fermentative activity of rumen micro-organisms, thus improving the supply of microbial protein to the lower tract,
- the extra amino acids absorbed as a result of feeding more ruminal escape protein may be used with high efficiency as an amino acid source for body protein synthesis, but they may also alter the hormonal balance e.g. between growth hormone and insulin and improve growth through lean tissue growth. Similarly, beneficial effects of UDP supplementation to cows in early lactation could also be due to alteration in the hormonal concentration of insulin and growth hormone apart from providing more amino acids to the mammary gland. Lower insulin and higher growth hormone levels are likely to favour tissue mobilization of fat and increase milk production (Walli and Mudgal, 1988).

The quality of undegraded protein from straws

The amount of undegraded protein entering the small intestines (SI) on straw diets is limited. A high proportion of this is cell wall bound protein and of low digestibility in SI (Hvelplund, 1985). The technique of mobile nylon bag, containing the rumen undegraded residue, after removing the microbes attached to feed particles and inserting through abomasum was used by Hvelplund (1985). Table 2 compares digestibilities in rumen and small intestine and indicates a low quality availability of undegraded protein in untreated and ammonia treated barley straw in the lower tract. Negi *et al.* (1988) found that while the N degradability of rice straw was lower than wheat straw, DUN (Digestible undegraded N = UDN - ADIN) was almost 5 times higher in rice straw than in wheat straw (Table 1). Calculated on this basis, the net absorbable N (RDN x 0.8 x 0.75 + DUN) from rice straw was found to be almost double that of wheat straw. Kumar and Walli (1989) observed that the flow rate of ADIN at the abomasum as a percentage of N intake was significantly higher

Table 1 Fractionation of total N in straws (g/kg DM).

N fraction	Rice straw I*	Rice straw II**	Wheat straw**
Total N	7.8	6.37	5.36
NDS-N	3.8(48.7%)	-	-
NDI-N	4.0(51.3%)	-	-
RDN	-	2.35(37%)	2.81(52.5%)
UDN	-	4.02	2.35
ADIN	2.2	1.07	1.77
DUN (dig. undegraded dietary N)	-	2.95	0.58
Dig UDN (%)	-	73.47	24.66
Dig NDIN (%)	54.0	-	-
Net absorbable N = (RDN x .8 x .7 + DUN)	-	4.27	2.15

* Oosting et al. (1990); ** Negi et al. (1988)

Table 2 N content, ruminal degradability and N digestibility in intestines for untreated and ammonia treated barley straw.

	Untreated Barley straw	Ammonia treated Barley straw
N content (% of DM)		
Straw	0.48	1.32
Rumen undegraded residue	0.37	0.72
Rumen disappearance (% of intake)		
DM	24	44
N	41	70
Intestinal disappearance (% of amount entering)		
DM	5.0	7.4
N	31.7	35.7

Source: Hvelplund (1989).

Table 3 Calculated values for RDN and UDN (g/kg DM) and ME (MJ/kg DM) for untreated and urea treated wheat straw and normal concentrate.

	Untreated straw	Urea treated straw	Normal concentrate
CP	35	80	200
Total N	5.6	12.5	32
N Deg. (Rumen %)	55	70	70
RDN	3.1	8.75	22
Digestible RDN (RDN x .8 x .75)	1.86	5.25	13.20
UDN	2.5	3.75	10
Dig. of UDN in SI (%)	30	35	90
Available UDN (or DUN)	0.75	1.3	9
Net absorbable N (Dig. RDN + DUN)	2.61	6.55	21.3
TDN	400	500	700
ME = (TDN x 15.23)	6.1	7.6	10.7

($P < 0.01$) for the urea treated wheat straw diet than for the untreated straw diet. The flow rate of non-ammonia N (as % of N intake) was similar on untreated wheat straw supplemented with formaldehyde treated groundnut cake compared with the urea treated straw supplemented with untreated cake, but the flow of -amino N (as % of N intake) was lower on the latter diet, which was due to the higher ADIN content in the undegraded N fraction from urea treated straw.

CALCULATIONS OF RDN, UDN AND ME AVAILABILITY FROM STRAW BASED DIETS

On the basis of the limited data available, the average values for the availability of nutrients viz. RDN, UDN and ME of straw DM have been worked out (Table 3). Of course, the more important protein fractions available to the host animal are the digestible UDN and RDN (RDN x 0.8 x 0.75) considering 20% of microbial acid N, and the digestibility of microbial protein as 75%. Thus, 1 kg of wheat straw DM could supply 3.1 g of RDN or 1.86 g of dig. RDN and 2.5 of UDN or 0.75 g of DUN (digestible undegraded N) apart from 6.1 MJ of ME. Similarly, the Figures were worked out for the urea treated wheat straw as, 8.75 g of RDN or 5.25 g of dig. RDN and 3.75 g of UDN or 1.3 g of dig. UDN and also 7.6 MJ of ME/kg of the DM.

In India and other tropical countries, livestock farmers with meagre resources and with a shortage of green fodder, mostly use straws and very little concentrates to feed their animals. An excercise was done to see how far these diets are able to supply the nutrients for growth and milk production with respect to ARC (1980) recommendations.

Nutrient supply from straw based diet for a growing animal

For the purpose of calculations and as a case study, an animal weighing 200 kg was considered. The maintenance requirements of such an animal are 36 g of RDN and 29 MJ of ME as per ARC (1980). The nutrient availability from straw based diets when either untreated or urea-treated straw is used as the basal feed for such an animal is given in Table 4. Feeding untreated straw as a sole diet supplies inadequate RDN and ME even to meet the maintenance requirement of the animal. However, when urea treated straw is fed as a sole diet to such an animal, it supplies adequate nutrients to support a growth rate of 100 - 150 g/day.

Supplementation of the untreated straw with 1 kg normal concentrate still does not provide nutrients for maintenance, RDN being short by 6 g, which could be met by feeding a little bit of green forage to the animal or by adding some urea in the concentrate. Supplementation with 2 kg concentrate supplies sufficient nutrients to support a growth rate of 250 g/day and the supplementation with 3 kg provides sufficient RDN but insufficient ME to support a growth rate of 500 g/day.

With urea treated straw, supplementation with just 0.5 kg of concentrate 10.5 MJ ME/kg will supply enough RDN and ME to support a growth rate of 250 g/day at a body weight of 200 kg, supplementation with 1.5 kg concentrate supplies enough RDN but insufficient ME for a 500 g/gain/day growth rate, which could be compensated by a little bit of greens or increasing the ME of the concentrate.

Table 4 RDN, UDN and ME availability from straw based diets for an animal weighing 200 kg.

DMI through feeds			DMI kg/100kg B.wt.	RDN (g/day)	UDN availability (g/day)	ME (MJ/d)	Sufficiency of RDN, ME and expected growth rate
Straw	Conc.	Total					
Untreated straw and concentrate							
3.6	-	3.6	1.8	11.2	2.7	22	(RDN, ME, less for maintenance)
3.3	0.90	4.2	2.1	30.0	10.6	29.7	(RDN less for maintenance)
2.6	1.80	4.4	2.2	47.7	18.2	35.7	(Both sufficient for 250 g/day gain)
2.1	2.7	4.8	2.4	65.9	24.3	41.7	(ME less for 500 g/day gain)
Urea treated straw and concentrate							
4.4	-	4.4	2.2	38.5	5.7	35.0	(Both sufficient for 150 g/day gain)
4.15	0.45	4.6	2.3	46.2	9.4	36.0	(Both sufficient for 250 g/day gain)
3.45	1.35	4.8	2.4	60.1	16.7	40.6	(ME less for 500 g/day gain

Nutrient supply from straw based diets for a lactating animal

Considering a 400 kg cow, it requires 58 g of RDN and 46 MJ of ME for maintenance. The nutrient availability from the diets containing either untreated straw or the treated straw as the basal feed is given in Table 5. On an untreated straw diet alone, the animal receives only 20 g of RDN and 39 MJ of ME, which is insufficient to meet the maintenance requirements of the animal. If the animal is fed urea treated straw as the sole diet the animal receives enough RDN and ME for 2-3 l of milk production per day.

By supplementing the untreated straw with 0.5 kg concentrate, there is enough ME, but insufficient RDN for the above mentioned cow. Addition of 30 g of urea in the concentrate or sprayed as a solution over the straw is the cheapest way to meet the full requirement of RDN for maintenance. Alternatively, the animal has to be provided with at least 5 kg of fresh leguminous fodder to meet its maintenance requirement RDN (30 g urea = 70 g CP, 5 kg fresh legume = 0.5 kg dry = 100 g CP) Supplementation with 4 kg of concentrate along with untreated straw could provide just sufficient RDN and ME required for producing 5-6 l of milk per day. For higher milk production (about 10 kg) green fodder such as berseem in the Northern region of India may be supplied to meet the energy requirement of the animal, alternatively, the proportion of ME in the concentrate need to be increased.

Urea treated straw, supplemented with 1 kg of concentrate, provides enough RDN and ME to meet the requirement for an animal of 400 kg BW to produce 5 l of milk per day. As also stated above, UDP is not required at these levels of production. Supplementation with 3 kg of concentrate per day can meet the RDN requirement for 10 l of milk per day, but the ME availability becomes limiting, which need to be compensated by providing some green fodder like maize and/or by increasing the proportion of ME in the diet.

- Metabolizability of feeds: ARC (1980) suggests that for an animal weighing 100 kg and growing at 0.5 kg/d, the RDP/UDP ratio changes from 88 : 12 to 73 : 27 and the requirement for total protein (RDP + UDP) from 270 g to 260 g/d, as the metabolizability of the feed (ME/GE) increases from 0.4 to 0.7. The slight decrease in total protein requirement could be explained by the better digestibility of UDP than the microbial protein arising from RDN in the rumen.
- Growth: NRC system uses the term DIP (degradable intake protein) and UIP (undegradable intake protein). As per ARC (1980), an animal of 200 kg LW and gaining up to 500 g/day can meet all its protein requirement from RDP alone, whereas NRC (1989) recommends 87% DIP and 13% UIP (Table 4). The CP and ME requirements suggested by NRC are higher than ARC, however, the ratio of CP/ME is higher for ARC than for NRC.
- Milk production: With regard to milk production, also, the RDP : UDP ratio in the diet has been suggested to vary from 85 : 15 to 80 : 20 as the metabolizability of the diet increases from 0.5 to 0.7 for a cow weighing 400 kg and yielding 10 litres of milk/day of 4.9% fat. At the ME/GE ratio of 0.5 in the diet, a cow yielding 5 l of milk/day, could meet all its CP requirement through RDP, alone as per ARC recommendation, however, the NRC system recommends a ratio of 60 : 40 for DIP and UIP in the diet at all levels of milk production (Table 4). As in the case of growth, similarly for milk production, the CP and ME requirements suggested by NRC (1989) are higher than ARC (1980) and the CP/ME ratio is also much higher than as per ARC recommendations. For a cow weighing 400 kg and yield 10 l of milk/d of 4.5% fat and maintaining its weight, the CP and ME requirements were 965 g and 103 MJ and giving the ratio of CP/ME as 9.4 as per ARC (1980). However, the NRC (1989) requirement for a cow which is gaining 225 g/day in addition to yielding 10 l of milk/d of 4.5% fat was 1479 g of CP and 112.5 MJ of ME giving a ratio of CP/ME as 12.2.

  Utilization of body reserve in case of dairy: Both the ARC and NRC standards take into consideration the physiological status of the animal, with regard to weight gain or loss, pregnancy, fat and protein percent of milk, endogenous N-losses and N required for hair and scurf. Since milk production gets metabolic priority during lactation, there is a considerable demand for nutrients by the mammary gland. High yielding animals that do not receive enough nutrients from the feed will supply the demands of the mammary gland for extra nutrients through mobilization of body reserves (90% fat and

Table 5 RDN, UDN and ME availability from straw based diets for a cow weighing 400 kg.

DMI through feeds: Straw	Conc.	Total	DMI kg/100 kg B. wt.	RDN availability (g/d)	UDN availability (g/d)	ME availability (MJ/d)	Sufficiency of RDN, ME and expected milk yield
Untreated straw and concentrate							
6.75	0.45	7.2	1.8	30.8	9.1	46.0	(RDN too low for maintenance)
7.05	1.35	8.4	2.1	51.7	17.5	57.4	(ME enough for maintenance)
6.5	2.70	9.2	2.3	79.5	29.2	68.5	(ME slightly too low for yield of 5 l of milk/day)
Urea treated straw and concentrate							
8.8	-	8.8	2.3	77.0	11.5	66.9	(Both RDN and ME sufficient for 2-3 l/day)
8.3	0.90	9.2	2.3	92.4	18.9	72.7	(Both RDN and ME sufficient for 5 l/day)
7.7	2.7	10.4	2.6	126.8	34.4	87.4	(ME less for 10 l of milk/day

Table 6 Nutrient requirements for growth and milk production (ARC versus NRC).

FOR A GROWING ANIMAL WEIGHING 200 KG

Nutrient fraction	Levels of growth rate (g/d): Zero	250	400	500
ARC				
RDN (g/d)	36	46.4	-	61.6
UDN (g/d)	-	-	-	-
CP (RDP + UDP) (g/d)	225	290	-	385
ME (MJ/d)	29	37	-	50
CP (RDP + UDP)/ME	7.7	7.8	-	7.7
NRC				
DIP	-	-	262.5	281.3
UIP	-	-	23.1	41.3
DIP+UIP	-	-	285.6	322.6
DIP/UIP	-	-	92/8	87/13
CP	-	-	362.5	400.0
ME	-	-	52.8	57.3
CP/ME	-	-	6.86	6.98

FOR A LACTATING ANIMAL WEIGHING 400 KG

Nutrient fraction	Levels of milk production (l/d): Zero	5.0	6.5	10.0	13.5
ARC					
RDN	58	92	-	131.0	-
No gain UDN	-	-	-	23	-
In body RDN/UDN	-	-	-	85/15	-
Weight CP	362.5	575	-	962.5	-
ME	46	74	-	103	-
CP/ME	7.88	7.77	-	9.34	-
NRC					
225 g DIP	-	-	706	-	1075
LWG/d UIP	-	-	465	-	712.5
DIP/UIP	-	-	60/40	-	60/40
CP	-	-	11171.2	-	1787.5
ME	-	-	93.6	-	131.7
CP/ME	-	-	12.5	-	13.57

10% protein), resulting in negative energy balance and weight loss, especially during early lactation. Feeding of bypass protein in such a situation could provide extra amino acids for the balance of nutrients or could enhance mobilization through increased growth hormone level.

FEEDING OF SLOWLY DEGRADABLE PROTEIN AND SUBSEQUENT EFFECT ON NUTRIENT UTILIZATION

Feeding of diets of lower protein degradability viz. fish meal and formaldehyde or heat-treated meals has been found to decrease the OM digestibility compared to the diets of higher RDP value (Zerbini *et al.*, 1988). However, nutrient digestibilities were also reported to be similar when feeding diets containing variable RDP/UDP ratio (Peterson *et al.*, 1985; Kennelly *et al.*, 1986).
Growing animals that were fed with proteins of lower RDP value showed increased N retention and a simultaneous decrease in urinary N excretion than when proteins of higher RDP value were fed (Wanapat *et al.*, 1982; Kurilor *et al.*, 1988; Walli *et al.*, 1989). The N retention in lactating cows was also improved by infusion of casein into the abomasum (Cohick *et al.*, 1986). The flow rates of non-ammonia N and amino N at abomasum (as % of N intake) given in Table 7, were highest on urea treated straw supplemented with low degradable protein, followed by untreated straw plus low degradable protein and lowest on untreated straw plus highly degradable protein (Kumar and Walli, 1989).

Table 7 Flow rate of N fractions at abomasum (as % of N intake) on untreated or urea treated wheat straw supplemented with a concentrate containing either untreated or HCHO treated groundnut cake.

N fractions	Untreated straw + untreated cake	Untreated straw + treated cake	Treated straw + untreated cake	Treated straw + treated cake
NAN**	76.4 ^{a}	83.6 ^{b}	84.4 ^{b}	91.3 ^{c}
NANUN**	75.3 ^{a}	82.5 ^{b}	82.6 ^{b}	89.7 ^{c}
NADN (NANUN-ADIN)**	62.0 ^{a}	70.4 ^{b}	64.5 ^{a}	73.4 ^{b}
Amino N**	59.6 ^{a}	68.3 ^{b}	62.5 ^{a}	71.7 ^{b}

** $p < 0.01$

FEEDING OF SLOWLY DEGRADABLE PROTEIN FEEDING AND ITS EFFECT ON GROWTH PERFORMANCE

Growth rate of lambs fed straw based diets supplemented with casein (treated with HCHO) plus urea was significantly higher than those fed untreated casein (Kempton and Leng, 1979). Gupta and Walli (1987) also found a significant increase in the growth rate of kids fed formaldehyde treated groundnut cake as part of the diet. When an ammoniated wheat straw was fed along with supplements like blood meal or soybean meal, the average daily gain of animals was significantly increased relative to untreated straw (Nelson *et al.*, 1985). Kumar *et al.* (1988) observed that cross-bred heifers fed ammoniated straw supplemented with groundnut cake, treated or untreated with formaldehyde grew faster than the animals given fishmeal instead. Kumar and Walli (unpublished) measured the growth rate and feed conversion efficiency in cross-bred calves (Table 8). The efficiency of nutrient utilization for growth was better for untreated straw and slowly degradable protein than for ammoniated straw and slowly degradable protein.

Several workers conducted dose response studies on supplementation of straw diets with slowly degradable protein. Saadullah (1984) observed little benefit of fishmeal supplementation beyond 50 g/d to untreated rice straw in calves. Wanapat *et al.* (1986) reported the LWG of 0.47, 0.81 and 0.93 kg/d, when rice straw was supplemented with 1, 2 and 3 kg of concentrate containing 65.6% rice bran and 10.9% soybean meal. The increase in LWG during these experiments could be due to an increase in ME intake in addition to that of supply of amino acid at tissue level for protein synthesis. Perdok and Leng (1987) reported linear increase in live weight gain/d by supplementing NH_3 treated rice straw with graded levels of protein meal (0.4, 0.8 and 1.2 kg) largely consisting of slowly degradable protein.

Sampath *et al.* (1989) achieved an average gain of 0.5 kg/day, in cross-bred calves by supplying 25 percent more RDP and ME than recommended by ARC (1984) suggesting thereby that more studies of this nature are needed to work out the RDP, UDP and ME requirements and supply under Indian conditions. When leucaena leaf (LL) was supplemented to urea treated straw 1 kg fresh basis (205 g DM), the weight gain was significantly improved in calves (Cheva Isarakul, 1987). The medium ruminal N degradability (50-90%) of LL not only resulted in significant increase in DOMI but also doubled the quantities of dietary protein escaping the rumen, when fed at levels of 30% DMI.

Table 8 Growth rate and feed conversion efficiency for cross-bred calves fed untreated or urea treated straw supplemented with concentrate containing either untreated or HCHO treated groundnut cake

N fractions	Untreated straw + untreated cake	Untreated straw + treated cake	Treated straw + untreated cake	Treated straw + treated cake
LWG (g/d)	443	473	504	536
DMI (kg/100 kg. B.W.)*	2.4 [b]	2.3 [b]	2.6 [a]	2.6 [a]
DMI (g/kg $W^{0.75}$)**	86.7 [b]	82.8 [b]	96.6 [a]	95.8 [a]
Feed : gain (kg/kg gain)	9.4	8.0	9.5	9.2
Feed cost (INR/kg LWG)	13.8	12.5	13.9	14.2

* $p < 0.05$; ** $p < 0.01$

FEEDING OF SLOWLY DEGRADABLE (UDP)PROTEIN AND ITS EFFECT ON LACTATION PERFORMANCE

Ørskov *et al.* (1977) observed that post ruminal infusion of casein not only increased milk yield, but also significantly increased milk protein content in high producing cows, which were further increased during restricted energy intake. Post ruminal supplementation of cows with casein also increased milk yield by 1 to 4 kg/cow/day, and the milk protein yield by 10-15% in results reported by Clark (1975). Ørskov and McDonald (1981) also found an increase in FCM yield and milk protein content when cows were fed diets containing fish meal compared to ones containing groundnut cake. Similar observations were made by Forester *et al.* (1983). However, the findings of other workers did not show any increase in milk yield on diets having lower protein degradability (Erdman and Vandersall, 1984; Murphy and Kennelly, 1986). Saadullah (1984) observed a linear increase in milk yield in zebu cows when graded level of fish meal was given as a supplement to the basal diet of ammoniated rice straw. Perdock (unpublished data) found 20% increase in milk yield from 2.6 to 3.2 l/day and 8% increase in fat content when urea treated straw was supplemented with 1 kg coconut cake, possible due to the slower degradability of the coconut cake protein in the rumen. Factors like stage of lactation and the level of production may cause the variable response to feeding of slowly degradable. Oldham (1984) postulated that the response to increased input of amino acids depends both on the physiological status of a cow, i.e. the stage of lactation of the cow and the condition of body reserves and the balance of all nutrients absorbed from the gastro-intestinal tract.

CONCLUSIONS

Untreated straws contain insufficient energy and RDN even for the maintenance of the animal. The degradability of N from straw in the rumen is higher than is generally assumed. Addition of RDN to the diet helps only to achieve moderate levels of growth and milk production. At higher production levels ME becomes a limitation.

There appears to be a scarcity of data to substantiate the claim that feeding of slowly degradable proteins has beneficial effects on the animal performance in tropical countries. Thus, there is an urgent need to conduct trials using different dietary RDP:UDP ratio in straw based diets to examine the relevance of adopting RDP/UDP system of feeding low producing animals.

REFERENCES

ARC, 1980. The nutrient requirements of ruminant livestock. Commonwealth Agricultural Bureau, Slough, U.K.

ARC, 1984. The nutrient requirement of farm livestock. Supplement No. 1. Commonwealth Agricultural Bureau, Slough, U.K.

Armstrong, D.G., 1980. TITLE ?? , pp. 400-413. In: H.J. Oslage and K. Rohr (eds): TITLE ?? 3rd EAAP Symp.

Protein Metabolism and Nutrition. EAAP Publ. No. 27. Braunschweigh.
Cheva-Isarakul, B., 1987. Performance of sheep fed urea treated/molasses supplemented straw with or without fresh Leucaena supplement with fresh grass, pp. 225-232. In: R.M. Dixon (ed.): Ruminant Feeding System Utilizing Fibrous Agricultural Residues. Canberra, Australia.
Clark, J.H., 1975. Lactational response to post ruminal administration of protein and amino acids. J. Dairy Sci., 50: 1178-1197.
Cohick, W.S., Vicini, J.L., Staples, C.R., and Clark, J.H., 1986. Effect of intake and post-ruminal casein infusion on performance and concentration of hormones in plasma of lactating cows. J. Dairy Sci. 69: 3022-3032.
Durand, M., 1989. Conditions for optimizing cellulolytic activity in the rumen, p. 3-18. In: M. Chenost and P. Reiniger (eds): Evaluation of straws in Ruminant Feeding. Elsevier Applied Science, England.
Egan, A.R., 1988. Ration formulation and evaluation of protein provisions from diets of mixed components with particular reference to milk production systems in India, pp. 168-179. In: Kiran Singh and J.B. Schiere (eds): Fibrous Crop Residues as Animal Feed. ICAR, New Delhi, India.
Erdman, R.A., and Vandersall, J.H., 1983. Effect of rumen protein degradability on milk yield of dairy cows in early lactation. J. Dairy Sci. 66: 1873.
Forester, R.J., Grieve, D.G., Buchanan Smith, J.G., and MacLeod, G.K., 1983. Effect of dietary protein degradability on cows in early lactation. J. Dairy Sci. 66: 1653.
Gupta, H.K., and Walli, T.K., 1987. Influence of feeding formaldehyde treated groundnut (GN) cake and its partial replacement with urea on growth and feed utilization in cross-bred kids. Ind. J. Anim. Nutr. 4: 94.
Harrison, D.G., and McAllan, A.B., 1980. pp. 205-226 in: Ruckebusch and P. Thivend (eds): Digestive Physiology and Metabolism of Ruminants. M.T.P. Press Ltd., Lancaster.
Hvelplund, T., 1989. Protein Evaluation of treated straw, pp. 66-74. In: M. Chenost and P. Reiniger (eds): Evaluation of straws in ruminant feeding. Elsevier. applied Sci. England.
Kempton, J.J., and Leng, R.A., 1979. Protein nutrition in growing lambs. 1: Response in growth and rumen function to the supplementation of low protein cellulosic diet with either urea, casein or formaldehyde treated casein. Brit. J. Nutr. 32: 289.
Kennelly, J.J., Ha, J.K., and Berzins, R., 1986. Effect of dietary nitrogen source on microbial protein synthesis, dietary protein degradation and nutrient digestion in steers. Anim. Fd. Sci. and Techn. 14: 117.
Kristensen, E.S., Moller, P.D., and Hvelplund, T., 1982. Estimation of the effective protein degradability in the rumen of cows using the nylon bag technique combined with the outflow rate. Acta Agriç. Scand. 32: 123-127.
Kumar, A., Naik, D.G., and Prasad, R., 1988. Effect of feeding formaldehyde treated protein supplements with urea treated wheat straw based diets on nutrient utilization and growth in cross-bred heifers. Ind. J. Anim. Nutr. 5: 296.
Kumar, V., and Walli, T.K., 1989. The flow rate of NAN and -amino N at abomasum in cross-bred calves fed urea treated straw supplemented with bypass protein, 20th Conf. on "Rumen Function" Chicago, Nov. 7-9, Abstract.
Kurilov, N.V., Korshinov, V.N., Sevast, Yanova, N.A.T., and Rakhnov, I.K., 1988. Digestion in cows given protein protected to varying degree rumen degradation. Nutr. Abstr. and Reviews. (Series B) 58: 5291.
Mould, F.L., Ørskov, E.R., Mann, S.O., 1983/84. Associative effects of mixed feeds I. Effects of type of supplementation and influence of rumen fluid pH on cellulysis in vivo and dry matter digestion of various roughages. Anim. Fd. Sci. Techn. 10: 15-30.
Murphy, J.J., and Kennelly, J.J., 1986. Effect of level of UDP in the diet on the performance of dairy cows (Abstr.). J. Dairy Sci. 69 (Suppl. 1): 218.
Negi, S.S., Singh, B., and Makkar, H.P.S., 1988. In situ rumen degradation of dry matter and N in some concentrate feed supplements. Ind. J. Anim. Nutr. 6: 1-12.
Nelson, M.L., Rush, I.G., and Klopfenstein, T.J., 1985. Protein supplementation of ammoniated roughage II. Wheat straw supplemented with alfalfa, blood meal and soybean meal fed to winterring steers. J. Anim. Sci. 61: 245.
NRC, 1989. Nutrient requirement for dairy cattle, 6th Revised Edition, National Research Council Washington, D.C.
Oldham, J.D., 1984. Protein energy interrelationship in dairy cows. J. Dairy Sci. 67: 1090-1114.
Ørskov, E.R., Grubb, D.A., Kay, R.H.B., 1977. Effect of post-ruminal glucose or protein supplementation on milk yield and composition in Friesian cows in early lactation and negative energy balance. Br. J. Nutr. 38: 397.
Ørskov, E.R., and McDonald, I., 1981. The effects of protein degradability and feed intake on milk yield and composition in cows in early lactation. Br. J. Nutr. 45: 547.
Perdok, H.B. and Leng, R.A., 1987. Hyperexcitability in catted fed ammoniated roughages. Anim. Fd. Sci. and Techn. 17: 121-143.
Peterson, M.K., Clauton, D.C., and Britton, R., 1985. Influence of protein degradability in range supplements on abomasal N flow, N balance and nutrient digestibility. J. Anim. Sci. 60: 1324.
Prasad, C.S., Sampath, K.T., Rai, S.N., and Joshi, A.L., 1993. Physical, chemical and morphological characteristics of slender and coarse straws and responses to urea treatment - a review.
Saadullah, M., 1984. Studies on utilization of rice straw by cattle. Ph.D. Thesis, Royal Veterinary University, Copenhagen.
Sampath, K.T., Prasad, C.S., and Sivaramiah, M.T., 1989. Effect of feeding different levels of rumen degradable protein and metabolizable energy on growth rate and nutrient utilization in cross-bred calves. Ind. J. Anim. Nutr. 6: 289-294.
Sampath, K.T., Prasad, C.S., Walli, T.K., and Shivaramaiah, M.T., 1993. Methods to assess the protein value

of feeds for ruminants. These proceedings.
Singh, B., and Negi, S.S., 1985. Utilization of ammoniated wheat straw by sheep. Ind. J. Anim. Nutr. 2: 31.
Varvikko, T., and Lindberg, J.E., 1985. Estimation of microbial Nitrogen in nylon bag residue by feed 15N dilution. Br. J. Nutr. 54: 473-481.
Walli, T.K., Singh, N., and Mudgal, V.D., 1989. Non ammonia nitrogen flow rate at abomasum fed different protein source, pp. 12-18. Proceedings "2nd World Buffalo Congress", New Delhi, India.
Walli, T.K., Ørskov, E.R., and Bhargawa, P.K., 1988. Rumen degradation of straws 3. Botanical fractions of 2 rice straw varieties and the effect of ammonia treatment. Anim. Prod. 46: 347.
Walli, T.K., Ørskov, E.R., and Bhargawa, P.K., 1990. Rumen degradability of two varieties of wheat straw and the effects of subsequent ammonia treatment. Indian J. Anim. Nutr. 7: 97-102.
Wanapat, M. Erickson, D.D., and Slanger, W.D., 1982. Nitrogen metabolism in sheep fed protein sources of various solubilities with low quality roughage. J. Anim. Sci. 34: 625.
Wanapat, M., Duangchan, S., Pongpairote, S., Anakewit, T., and Tongpanung, P., 1986. Effect of various levels of concentrate fed with urea treated rice straw for pure-bred American Brahman yearling cattle, pp. 149-153. In: R.M. Dixon (ed.): Ruminant Feeding System utilizing Fibrous Agricultural Residues. I.D.P., Canberra, Australia.
Zerbini, E., Polan, C.E., and Herbein, J.H., 1988. Effect of dietary soybean meal and fish meal on protein digesta flow in Holstein cows during early and mid lactation. J. Dairy Sci. 71: 1240.