THE KEY ROLES OF UREA AND PROTEIN SUPPLEMENTATION IN INCREASING PRODUCTIVITY OF RUMINANTS FED CROP RESIDUES OR PASTURE

by

R.A. Leng

Emaciated cattle and buffaloes in the herds of small farmers in developing countries have been usually diagnosed as being energy deficient. Whilst it is self evident that these animals, fed largely on crop residues, are deficient in nutrients and total energy intake, the low energy intake appears to be due primarily to a fermentable N and/or protein deficiency in the diet. The apparent energy deficiency is a result of an inefficient (fermentable - N deficient) rumen which decreases the rate of fermentative digestion and also decreases the ratio of protein to energy in the products of rumen fermentation (which are microbial cells (65% protein) and the VFA's). The effect of the low rumen fermentative activities is a reduced feed intake. Correcting a N deficiency for the rumen microbes increases feed intake, digestibility and the ratio of protein to energy in absorbed products, but because the nutrients arising from digestion in the rumen are imbalanced to meet the requirements for productivity this remains fairly low. However, when supplements of bypass nutrients are given, productivity then increases substantially and correcting both a fermentable-N and amino acid deficiency is synergistic in increasing ruminant production.

The need for supplements of protein, long chain fatty acids and glucose to cattle given diets based on crop residues has been discussed in a companion paper.

The majority of livestock in the developing countries depends on low protein forages (straw or dry grass) for a considerable period of each year. In addition, competition with humans for the available milk means that young animals are often denied their full requirement for milk (the best balanced supplementary feed). Cattle and buffalo in the tethered husbandry systems in Asia and cattle in grazing systems in such countries as Africa require to grow, conceive, support the foetus and yield milk whilst fed on these crop residues.

It is my conviction that N deficiency of ruminants is the primary constraint to increasing ruminant production from these feeds and that it affects all aspects including fertility, growth and other production functions and even mature body size. The alleviation of N deficiency in the rumen and protein deficiency in the animal must lead to enormous increases in animal production without recourse to concentrate feeding. The evidence for this is discussed below. It indicates that the so-called "poor quality" forages are adequate to support moderate levels of all productive functions of ruminants provided they are supplemented with 'catalytic' amounts of protein meals and particularly urea. The evidence for this is discussed below for productive functions and different physiological states.

Puberty - Puberty tends to be a function of bodyweight rather than age. Because Hereford heifers supplemented with a bypass protein meal grew faster and reached a critical bodyweight earlier than unsupplemented cattle, these heifers were able to breed one year earlier (Table 1).

Conception - In studies with mature Hereford cows with calves at foot, supplementation with a bypass protein meal during periods when only dry native pasture was available for grazing had a large effect on conception rate (Table 2).

Male fertility - In the wet/dry tropics of Australia bulls are often placed in a herd four to six weeks after the onset of the wet season even though the bulls may have lost 20% of their bodyweight. Increased fertility of bulls on dry winter pasture (i.e. low N-low digestibility forage) can be achieved by feeding a protein supplement daily (Table 3). Most importantly the circumference of the scrotum decreased considerably when no supplement was fed and thus these animals tend to be less fertile and have a lower libido since scrotal circumference is an index of these reproductive characteristics (see Blockey, 1980).

Rate of bodyweight gain - Examples of the benefits of N supplementation of young cattle or pregnant cows on dry spear grass pastures are given in Table 4 where the synergistic effects of both urea and a bypass protein are well demonstrated.

Viability of new-born animals - Supplementation of sheep grazing dry native pasture with urea through the drinking water, and supplementation of cattle given dry native grasses with urea sprayed on the feed, improved the body weight of lambs and calves respectively at birth and also their subsequent survival rate (Table 5).

Milk yield - Small inputs of urea (as a molasses/urea block) increased milk yield considerably in buffaloes fed largely straw-based diets under village conditions in India (Figure 1). Feeding small amounts of fish meal to cattle in Bangladesh on treated (urea) straw increased milk yield markedly (Figure 2).

Ultimate body size - Feeding a protein meal during the dry seasons to cattle on native pasture resulted in large weight gain advantages and the mature body size was increased (see Table 6).

Body size is related to draught-power. Many oxen in developing countries appear to be stunted which is possibly brought about by a protein deficiency at critical stages in their life.

The replacement of two undersize oxen by a single well grown oxen and the introduction of improved agricultural implements would increase the availability of feed resources for other ruminant livestock.

From the above discussion low protein undernutrition at critical periods may be the single most important cause of low productivity of cattle in traditional-subsistence farming/grazing systems in Africa as compared with cattle raised on ranches in the same country (Table 7). In subsistence as compared to ranching systems the great difference is that animals are of a much lower bodyweight particularly at weaning. This could be related to the high competition for available milk by humans (see Figure 3).

Conclusion

Protein and fermentable-N supplements to cattle fed crop residues or on pasture appear to be critical for all aspects of animal production from fertility and conception, to survival, growth, pregnancy and lactation. This simple strategy of supplementation, if widely applied, could have enormous effects on the availability of animal products in developing countries. Massive improvements are possible without recourse to the use of grain-based concentrates.

Although the role of the protein meal is not always that of providing amino acids to the animal and it may be possible to substitute protein at times with other nutrients (bypass starch or long chain fatty acids), the practical implications are that in all developing countries, efforts should be made to provide protected protein meals targeted at the animal production industries. The molasses/urea block appears to be fast becoming an established tool for providing urea to tethered ruminants (see Leng, 1984).

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Table 1 Liveweight of cows and proportion conceiving when offered a protein supplement when only dry pasture was available (Hennessy, 1985)

	Year and body weight			
	1978	1979	1980	1981
Bodyweight (kg)				
Controls	188*	254*	265*	300*
Supplemented 1	247*	300*	330*	378*
2	247	361*	390*	392*
Calving percentage (%)				
Control		0	67	45
Supplemented 1		91	62	64
2			67	100
Calf weaning weight (kg)				
Control	-	-	-	119
Supplemented 1	-	-	150	156
2	-	-	-	173

* - mated

All cows and calves grazed carpet grass pastures. Groups 1 and 2 were supplemented with 2.8 kg of a protein pellet twice per week during dry periods. Bulls were grazed with the heifers and with the control and supplemented 1 group in the first year and with all groups in the second year.

Table 2 Liveweight and conception rates of lactating beef cows (with first calf at foot) grazing native pasture and supplemented with 1.86 kg of an energy concentrate (molasses 85, cottonseed meal 12, urea 1.7 and monoammonium phosphate 1) or 1.5 kg of a bypass protein meal (cottonseed meal) during periods when only dry pastures were available. There were 12 cows per group (Hennessy, 1986).

Supplement	Liveweight (kg)	Pregnancy (%)
Nil	302	10
Energy	332	20
Bypass protein	343	60

Table 3 The effects of supplementation with 1 kg/d protected protein (80% formaldehyde-treated cottonseed meal, 10% meat meal, 10% fish meal) on the liveweight change, feed intake and scrotal circumference of bulls fed spear grass pasture hay (*Heteropogon contortus*) containing 0.4% N (Lindsay *et al.*, 1982)

	Control	Bypass protein
Initial weight (kg)	433.00	433.00
Liveweight change (kg)	-40.00	+14.00
Feed intake (kg DM/d)		
Roughage	5.55	7.74
Total	5.55	8.65
Change in scrotal circumference (mm)	20.00	0.70

Table 4 The effect of feeding urea/sulphur and bypass protein on hay (45% digestible, 0.4% N) intake and production of growing or pregnant cattle (Lindsay and Loxton 1981; Lindsay et al. 1982).

Supplement	Intake	Liveweight change (kg/d)
Growing cattle (170 kg liveweight)		
None	2.26	-0.41
Urea/sulphur	3.01	-0.32
Urea sulphur plus bypass protein (500g/d)	4.43	+0.22
Pregnant cattle (last 60 days)		
None	4.2	-0.81
Urea/sulphur	6.2	-0.31
Urea sulphur plus bypass protein (1 kg/d)	8.1	+0.75

Table 5 The effects of supplying urea and sulphur to pregnant cattle and sheep given low N, low digestibility mature pasture hays.

Species	Diet	Birth weight (kg)
Cattle	Native pasture hay*	22
Cattle	Native pasture hay + urea/sulphur*	31
Sheep	Native pasture hay**	2.9
Sheep	Native pasture + urea**	3.2

* After Lindsay *et al.* (1982). The hay was mature Heteropogon hay (spear grass)

** After Stephenson *et al.* (1981). The feed was mature Flinders grass hay.

Table 6 The effects of bypass protein supplements given only during the dry season on the mature body weight of Hereford female cattle (Hennessy,1985). The cattle were on trial from two years of age when they were approximately 150 kg liveweight through to seven years of age. The cattle in the supplemented group had one more calf than those in the unsupplemented group (Hennessy, 1985).

Age of cattle (years)	Body weight (kg)	
	Unsupplemented cattle	Cattle supplemented with bypass protein in dry season
3	197	264
7 (Mature)	320	397

Table 7 Productivity of cattle in four African countries under small-holder or ranch management systems (ILCA, 1985)

Country	Breed/system	Birth weight (kg)	Weaning weight (kg)	2 years weight (kg)	4 years weight (kg)
Mali	Sudanese Fulani				
	traditional	17	55	125	220
	ranch	21	79	220	280
Nigeria	White Fulani				
	traditional	20	55	140	240
	ranch	24	96	245	350
Ethiopia	Boran				
	traditional	20	55	150	260
	ranch	25	180	265	420
Botswana	Twana				
	traditional	26	120	260	300
	ranch	31	180	360	400

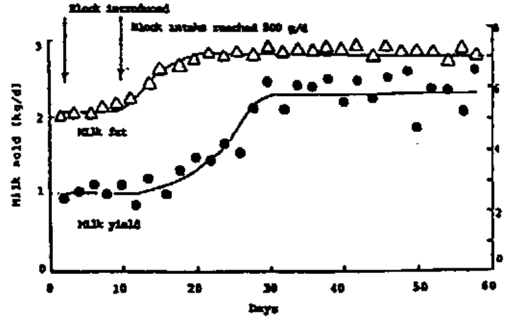

Figure 1 . The effects of introducing a molasses/urea block (20% urea) to a milking buffalo in a village in Mehsana, Gujarat, India. It took approximately 8 days before the buffalo consumed significant amounts of the block (500 g/d). Milk sold on its fat content (from records of milk sales) increased after a time lag of 7-10 days. The basal diet was millet straw with a handful of green forage (Kunju, Dave and Leng, 1985, unpublished observations).

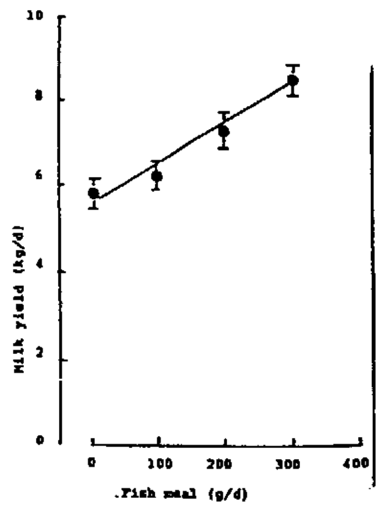

Figure 2 Milk yield of native and crossbred cattle fed ammoniated (urea-ensiling) rice straw supplemented with fish meal (range was 0-400 g/d) (from Saadullah, 1984).

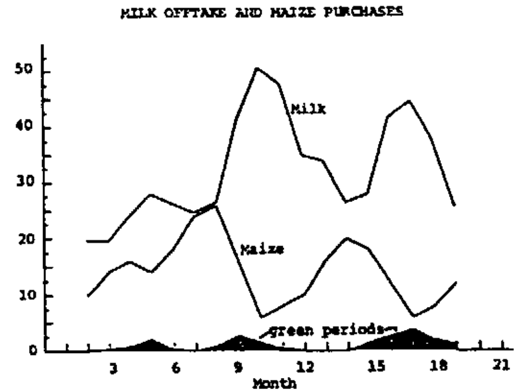

Figure 3. The influence of rainfall (active grass growth) on the milk offtake and maize purchases in Olkarkar ranch in Kenya. In periods of high milk production, maize purchases by the family are reduced, indicating substitution of cereal by milk in the family's diet. This shows the competition between human needs and those of the calves for available milk supplies (ILCA, 1985).