PROTEIN REQUIREMENTS OF RUMINATE'S - THE ARC PROPOSALS

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SUMMARY

An outline of the recent Agricultural Research Council (UK) proposals for assessing protein requirements of ruminants (ARC, 1980), is presented, The importance of considering both rumen degradable protein (RDP) and rumen undegradable protein (UDP) is noted. Calculations of the protein requirements and formulation of rations for (i) a high yielding' cow in early lactation and (ii) a growing/fattening steer gaining 1kg/day are shown.

In the second part of the paper the ARC system is examined in the light of some recent data relating to microbial protein production, in vivo degradability values for various feed proteins and the efficiency of utilization of non-protein N most obtained in studies with cattle. It is concluded that although, with the present state of knowledge, the factors proposed for use in the ARC scheme appear to provide a reasonable estimate of amino acid supply to the ruminant, further information is urgently required relating to specific feed protein sources,'

INTRODUCTION

For a very considerable period of time in the UK, protein requirements for ruminants and the capacity of feeds to meet the requirements have been based on digestible crude protein (DCP) and an extension of it to protein equivalent. The ARC (1965) proposals attempted to correct some of the known deficiencies in the system by expressing protein requirements in terms of available protein. This is then used to calculate the amount of digestible crude. protein needed in that amount of dry matter which meets the animal's energy requirement for the particular production situation,

In the light of recent understanding of protein (nitrogen) digestion in ruminants, the second, revised, edition of Nutrient Requirements of Farm Livestock, No. 2 Ruminants (ARC, 1980) has proposed a new scheme for assessing protein requirements of ruminants. The scheme encompasses the realisation that amino acid supply to the ruminant animal is provided as the sum of amino acids arising by digestion, within the small intestine; of microbialprotein passing from the rumen and that part of the feed protein which escapes degradation within the rumen.

The limitations of the DCP system and merits of the proposed scheme have been referred to by Roy, Balch, Miller, Orskov and Smith (1977) in a preliminary report of the new system and are given in full in ARC (1980). Suffice it to say that in view of the extensive transformation of ingested protein or non-protein nitrogen (NPN) compounds' occuring within

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the reticulo-rumen it is not surprising that special consideration has to be given to assessing protein (N) requirements for this class of livestock. Those responsible for the new proposals emphasize that, provided the basic concepts are correct, the factors proposed for use in the system at its creation must inevitably be subject to'modification as more extensive, relevant data become available - a concept that was equally true of the energy proposals contained in ARC (1965).

THE ARC SYSTEM

General Approach

Essentially two calculations are made: (i) the total tissue needs 'for amino acid N of the animal (TN) to meet the level of production required, using the factorial method (see Table 1), and (ii) the quantity

TABLE 1 Summary of data used to compute TN values (as protein) for cattle (ARC, 1980).

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i) Cattle, maintenance & growth: Tissue protein requirement = 6.25 x tissue N = sum of:

a) endogenous urinary N (as prot.) = $6.25(5.9206\log_{10}W - 6.76)$ g/d

b) dermal N loss (as prot.) = $6.25(0.018W^{0.75})$ g/d

c) protein in weight gain = $\Delta W(168.07 - 0.16869W + 0.0001633W^2) \times (1.12 - 0.1223\Delta W)$ (g/d) for castrates where ΔW = rate of live wt. gain kg/d.

ii) Cattle, additional requirement for pregnancy: For 40kg calf daily tissue protein retention (g/d) is:

$TP_{(t)} \times 0.03437 \exp. ^{-0.0026t}$ where t = no. of days from conception and $\log_{10}(TP_{(t)}) = 3.707 - 5.698 \exp. - 0.0026t$

iii) Cattle, lactation:

For no change in body weight, the TP requirement is the sum of:

a) endogenous uringery N as protein (see above)

b) dermal N loss (as protein) (see above)

c) Protein in milk (g/kg) = milk yield (kg/d) x protein concentration in milk g/kg,

Protein concentration in milk - Friesian cow = 6.25 x 4.8g/kg
Ayrshire cow = 6.25 x 5.0g/kg
Jersey cow = 6.25 x 5.7g/kg

Note: Tissue protein is assumed to be reduced by 56g/d for a weight loss of 0.5kg/d or increased by 75g/d for a weight. gain of 0.5kg/d.

iv) Comparable values for sheep - See ARC (1980).

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of amino acid N of microbial origin (TMN) available to meet the tissue requirements for amino acid N, resulting from the fermentation of dietary energy within the reticulo-rumen. The dietary N used to supply the micro-organisms with their N requirement is termed rumen degradable N (RDN). If TMN > TN then the N requirement of the animal is that designated RDN, If TN'> TMN then the difference must be supplied by amino acids of dietary origin that pass undegraded through the reticulo-rumen, and this, expressed in terms of N supply is called undegraded dietary N (UDN). In this 'instance total dietary N required is the sum of RDN and UDN,

In order to compute values for TN, TMN, RDN and UDN various factors, are used and these are given in Table 2.

. TABLE 2 Factors used tocompute values for RDN and TMN (ARC, 1980)

i) 1kg digestible organic matter (DOM) = 19.0 MJ DE.

ii) proportion of DOM intake (DOMI) lost as methane and in urine: 0.18.

iii) proportion of DOMI apparently digested in the rumen = 0.65.

iv) microbial N yield from rumen = 30g microbial N/kg DOM apparently digested therin.

v) proportion of amino acid N in total N of rumen microbes = 0.8.

vi) efficiency of absorption of amino acid N from small intestine=0.7.

vii) efficiency of utilization of absorbed amino acids = 0.75,

Relationship between protein (N) requirement and metabolisable energy intake

From a consideration of N/energy relationships in ruminant digestion. and metabolism, which are given in full in ARC (1980) and outlined briefly in Table 3, it is possible to 'calculate values for RDN, TMN and UDN from the metabolisable energy intake (ME) (MJ/d) required to achieve the level of production desired, or obtainable. This is very appropriate since it is a fundamental of nutrition that the energy requirement is primary and 'will, in the great majority of instances at least, be satisfied at the expense of the requirement for protein,

TABLE 3 Relationship between requirements (gN/d) for RND, TMN and UDN and metabolisable energy (ME) requirement (MJ/d) (ARC, 1980)

(i) RDN (g/d) $= ME \times \frac{1}{0.82 \times 19} \times 0.65 \times 30$

$= 1.25 \times ME$

(ii) TMN (g/d) $= RDN \times 0.80 \times 0.70 \times 0.75$

$= 0.53 \times ME$

(iii) UDN $= \frac{TN - TMN}{0.75 \times 0.70} = \frac{TN - 0.53ME}{0.75 \times 0.70}$

$= 1.91TN - 1.00ME$

Estimation of undegradable protein

As a result of microbial fermentation in the rumen, dietary proteins undergo proteolysis in the rumen to a greater or lesser extent to yield peptides and subsequently amino acids; these, or that part of them not directly taken up by the rumen micro-organisms, are subject to deamination yielding ammonia N. The extent to which a particular source of dietary protein undergoes these degradative processes is a characteristic of the kind of protein, the nature and amount of the diet, pH conditions within, and rate of flow of digesta through the rumen.

Undegraded dietary protein (UDP) equals UDN x 6.25 is that part of the dietary crude protein (CP) which 'is not degraded during passage of digesta through the rumen and which subsequently enters the small intestine. Degradability is thus measured as $\frac{RDP}{CP}$, where CP = RDP + UDP and RDP = RDN x 6.25.

Currently, a lot of attention is being given to determining the degradability of dietary proteins and this important aspect will be commented upon later in this paper. Until more 'reliable data become available, ARC (1980)has classed feeds into one of four broad categories of degradability (see Table 4). Application of degradability values to a particular feed or combination of feeds permit calculation of the actual amounts of RDP and UDP supplied in the ration.,

TABLE 4 Suggested grouping of some important dietary protein sources for degradability (ARC, 1980)

Class	Range of degradability	Forages	Cereals	Protein supplements
A	0.71 - 0.90	grass & legume hays dried grass (chopped) grass silage (wilted and unwilted)	barley	groundnut meal sunflower meal soyabean meal (unheated) rapeseed meal field bean meal yeast protein
B	0.51 - 0.70	grass & legumes (fresh) dried grass (ground & pelleted) dried legume chopped (except sainfoin)	maize	soyabean meal (cooked), lupin meal, coconut meal, fishmeal (white)
C	0.31 - 0.50	dried legume (ground & pelleted)	milo	fishmeal (Peruvian)
D	<0.31	grass silage (formal-dehyde-treated) dried sainfoin (chopped)		

The use of non-protein nitrogen (NPN) supplements

From the foregoing it will be appreciated that dietary NPN can only be used to correct a deficiency of RDP in the diet and in these circumstances ARC (1980) has proposed that such dietary N additions are used with an efficiency of 0.80, i.e. for every g NPN added to the diet 0.8g N are converted to microbial protein. Further comment upon this aspect will also be made later,

If urea is to be used as the NPN source to correct a deficiency of dietary RDP then, assuming it contains 460g N/kg urea, and allowing for an efficiency of utilization of 0.80, the amount of urea required'to be added to the diet (g/d) can be calculated from the equation;

$$\text{wt. of urea (g/d)} = \frac{\text{deficit of RDP}}{0.46 \times 6.25 \times 0.8} = \frac{\text{deficit of RDP}}{2.30}$$

where deficit of RDP = RDP required (Based on 30g microbial N/kg OM apparently digested in the rumen) - RDP actually supplied

= (1.25 ME x 6.25) - (CP of ration x degradability factor).

It must be noted that if there is a deficit of both RDP and UDP in the ration the deficit of UDP must first be. corrected by choice of'a protein supplement with an appropriate degradability factor, After allowing for the associated RDP supplied by this protein supplement, then if there is still a deficiency of RDP this can be corrected by the use of an appropriate amount of NPN, as shown for urea immediately above,

REQUIREMENTS OF CRUDE PROTEIN AND FORMULATION OF A RATION FOR A HIGH-YIELDING DAIRY COW IN EARLY LACTATION

Table 5 shows the calculation of the requirements of RDP and UDP for a 600kg dairy cow yielding 30kg milk/d, Since the cow is in early lactation she may be losing 0.5 kg liveweight/d and this loss will include a small contribution to tissue N requirement (56g protein/d),. It can be 'seen that if the ration formulated met exactly the RDP and UDP requirements it would have a crude protein content of 133g/kg feed DM.

TABLE 5 Calculation of the protein requirement of a non-pregnant, 600kg Friesian cow in early lactation giving 30kg milk/d (36g/kg BF; 85g/kg SNF) - allowing for a 0.5kg/d weight loss

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(Note: ME requirements and dry matter intake taken from MAFF Technical Bulletin 33 (1976) HMSO)

i) ME required = 63 + (30 x 4.9) - 14 = 196MJ/d

ii) Dry matter intake = 15.5kg/d

iii) Tissue N requirement (TN) = N in milk + endogenous N + N in scurf & hair - body tissue loss.

= (30 x 4.8) + 9.7 + 2.2 - 9.0
= 146.9

(iv) Rumen degradable N rquirement (RDN) = 1.25 x ME = 1.25 x 196
= 245g/d

(v) Total microbial amino N supplied to tissues (TMN) = 0.53 x ME
= 103.9.

(vi) Undegraded protein (N) requirement (UDN) = 1.91 x TN - 1.00 x ME
= 1.91 x 146.9 - 196
= 84.6

(vii) Therefore Dietary N requirement = RDN + UDN = (245 + 84.6)
= 329.6gN/d.

(viii) Expressing these values in terms of crude protein i.e. x (N x 6.25)

Dietary crude protein requirement = (RDP + UDP) = 6.25(245 + 84.6)
= (1531 + 529)
= 2060.

(ix) Therefore Dietary minimum crude protein concentration required*

$$= \left(\frac{2060}{15.5}\right) g/kg$$

= 132.9g/kg

(x) Degradability of crude protein in whole ration = $\frac{1531}{2060}$ = 0.74

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*This minimum value would only be realised if the ration as formulated to meet these requirements supplied exactly the amounts of RDP and UDP required.

Using the feeds detailed in Table 6, formulation of a ration to meet the requirements given in Table 5 is shown in Table 7, Ration 1, containing only hay and barley, although it meets dry matter and energy

TABLE 6 Feeds to be used in formulating a ration to meet the energy and protein requirements of the 600kg cow yielding 30 litres milk daily - specified in Table 5. The majority of data in this Table are from MAFF Technical Bulletin No. 33.

	DM (mg/kg)	ME (MJ/kgDM)	CP (g/kgDM)	Degrad. of CP	RDP (g/kgDM)	UDP (g/kgDM)
Hay	850	8.4	85	0.80	68	17
Barley	860	13.7	108	0.80	86	22
Soyabean meal	900	12.3	503	0.80	402	101
Herring meal	900	11.1	701	0.40	280	421
Urea	1000	-	(2875)	1.00	(2875)	0

requirements, is of course, inadequate in both RDP and UDP. The inclusion, of a specified amount of soyabean meal (Ration 2) results in a diet adequate in dry matter, energy and UDP but containing an excess of RDP and this is reflected in the high crude protein concentration in the ration dry matter viz, 171g/kg DM. Reducing the daily intake of soyabean meal from 2.9 to 0.6kg/d and adding 0.5kg herring meal, 'with slight adjustments in the amounts of hay and rolled barley fed (Ration 3) meets

TABLE 7 Rations formulated to energy requirements and finally protein requirements of the 600kg cow producing 30kg milk/d detailed in Table 5; using the feeds given in Table 6,

	Intake of feed ('as fed basis')	DM intake kg/d	ME intake MJ/d	RDP (Intakes of (g/d))	UDP (Intakes of (g/d))	CP (Intakes of (g/d))	degradability of protein	CP g/kg DM
1. Requirements	-	≤ 15.5	196	1531	529	2060	0.74	>133
2. Ration 1.								
Hay	3.6	3.1	26	209	52	261	0.80	-
Barley	14.4	12.4	170	1073	268	1341	0.80	-
	18.0	15.5	196	1282	320	1602	0.80	103
		satisfactory	balanced	deficient			too high	
3. Ration 2.								
Hay	2.8	2.4	20	163	41	204	0.80	-
Barley	12.2	10.5	144	907	227	1134	0.80	-
Soyabean meal	9.2	2.6	32	1046	261	1307	0.80	-
	17.9	15.5	196	2116	529	2645	0.80	171
		satisfactory	balanced	excess	balanced		too high	
4. Ration 3.								
Hay	3.3	2.8	23	188	47	236	0.80	-
Barley	13.7	11.8	162	1020	255	1274	0.80	-
Soyabean meal	0.6	0.5	6	205	51	256	0.80	-
Herring meal	0.5	0.4	5	118	176	294	0.40	-
	18.1	15.5	196	1531	529	2060	0.74	133
		satisfactory	balanced	balanced	balanced		correct for minimum CP content (g/kg DM)	

requirements of dry matter, energy, RDP and UDP with no excesses of either of the last two mentioned and brings the CP concentration down to 133g/kg DM. The replacement of a considerable part of the soyabean meal by a much smaller. amount of the markedly lower degradable herring meal has resulted in the protein of the whole ration having a degradability of 0.74 which is the value required to achieve a minimum crude protein concentration in the feed dry matter. If the ration as formulated has a higher or lower protein degradability than 0.74 then additional CP in the diet dry 'matter is require in the first instance it would provide an excess of RDP with UDP balanced,, in the second instance it would provide the correct amount of RDP but an excess of UDP.

The above example has beenchosen to illustrate various features of the ARC (1980) system, The ration as finally formulated would be very likely. to induce a low milk fat 'problem since the ratio of forage: concentrate is 1:4.

REQUIREMENTS OF CRUDE PROTEIN AND FORMULATION OF A RATION FOR A 300kg STEER GAINING 1kg/d

Table 8 shows the calculation of the requirements for RDP AND UDP for a 300kg steer of medium sized breed gaining 1kg/d and fed a ration of rolled barley and barley straw (spring), The energy requirements of the steer and analysis of feeds are taken from MAFF Technical Bull, 33; the degradability of barley straw crude protein has been assumed to be 0.80. It can be seen from Table 8 that if RDP and UDP requirements are exactly met by the ration to be formulated it will have a crude protein concentration in the dry matter of 84g/kg.

TABLE 8 Calculation of protein requirement of a 300kg steer gaining 1kg/d LW gain

1. It is assumed that intake of dry matter will be 2.3% LW i.e. 6.9kg/day and the feeds to be used are:

   (i) rolled barley: 860gDM/kg; ME 13.7 MJ/kg; CP = 108g/kg and degradability = 0.80.

   (ii) barley straw (spring): 860gDM/kg; ME 7.3MJ/kg; CP = 38g/kg and degradability = 0.80.

   From Technical Bull, 33, ME for maintenance = 36MJ and to meet ME requirements minimum M/D value of 10MJ/kg should be satisfactory (see Table 11, Bull. 33) i.e. total ME intake = 69MJ/d. Calculation shows that to meet energy requirements 2.9kg DM barley and 4.0kg DM straw should be fed daily,'

2. Ration

Ration constituents	DM g/kg	ME (MJ)	/kg DM CP (g)	degrad.	RDP (g)	UDP (g)
Rolled Barley	860	13.7	108	0.80	86.4	21.6
Barley Straw	860	7.3	38	0.80	30.4	7.6

3. Calculation of UDP and RDP requirementsa

   (i) RDN = 1.25 x ME = 86.25gN/d therefore RDP = 6.25 x 86.25 = 539g/d

   (ii) UDN = 1.91TN - 1.0 x ME

TABLE 8 (continued)

but TN = Endog. urinary N + N in gain + N in scurf
= 7.9 30.2 1.3 (from ARC 1980)
= 39.4

therefore UDN = 1.91 x 39.4 - 69 = 6.3
therefore UDP = 6.3 x 6.25 = 39.4
and degradability $= \frac{539}{(539 + 39.4)} = 0.93$

4. Minimum concentration of crude protein: Assuming a dry matter. intake of 6.9kg/d, the minimum crude protein in the ration would be:

$$\frac{(539 + 39)}{6.9} = 83.8\text{g/kgDM}$$

Table 9 gives details of the formulation and'itcan be seen that barley and straw alone, in the amounts adequate to meet the energy requirement, provides a small excess of UDP but is markedly deficient in RDP. Under these conditions no weight is given to the surplus UDP but the deficit of RDP is made good by the use of an appropriate amount of non protein N in the form of urea supplied at the rate of 10.5g/kg feed dry matter. Due to the slight excess of UDP and to the fact that NPN is only assumed to be 0.80 efficient in meeting RDP requirements, the . overall crude protein content of the ration (total N x 6.25) becomes 98g/kg DM which is a little higher than the minimum of 84g/kg DM.

TABLE 9 Formulation of ration to meet the requirements for energy, RDP and UDP of the 300kg steer gaining 1kg/d

	Intakes of (g/d)							
	Intake of feed ('as fed basis')	DM intake (kg/d)	ME intake (MJ/d)	RDP	UDP	CP	degradability of protein	CP (g/kg DM)
1. Requirements:		≤ 6.9	69	539	39.4	578	0.93	84
2. Ration:								
Barley	3.4	2.9	39.7	250.6	62.6	313.2	-	
Barley straw	4.7	4.0	29.2	121.6	30.4	152.0	-	
	8.1	6.9	68.9	372.2	93.0	465.2	0.80	67
		satisfactory	balanced	deficient	excess			

3. To correct deficit of RDP:

wt. of urea (g/d) $= \frac{\text{deficit of RDP}}{2.30} = \frac{167}{2.30} = 72.6$

therefore 10.5g urea/kg DM of rationmust be used.

4. The crude protein content of the ration of barley and barley straw plus urea

$$= \frac{372 + \frac{167}{.80} + 93}{6.9} = 97.6\text{g/kg DM}$$

Table 10 shows the comparison between the crude protein contents of the rations formulated in Tables 7 and 9, derived from ARC (1965) and those based upon ARC (1980). With references to the high-yielding dairy cow, it can be seen that DCP requirements are independent of the source of protein concentrate used and that in Terms of CP concentration in feed

TABLE 10 A comparison of ARC (1965) and ARC (1980) protein requirements for examples detailed in Tables 7 and 9.

		ARC (1965) DCP (g/kgDM)	ARC (1965) CP (g/kgDM)	ARC (1980) CP (g/kgDM)
(i) 600kg cow in early lactation yielding 30kg milk/d	Ration 2*	114	146	171
	Ration 3*	114	146	133
(ii) 300kg steer gaining 1kg/d	Ration 2**	56	84+	98‡

+Ration would contain 5.5 urea/kgDM

‡Ration would contain 10.5 urea/kgDM

*See Table 7

**See Table 9

dry matter the value is 146g/kg. On the other hand with the new proposals (ARC, 1980) if soyabean meal is used as the sole protein concentrate 171gCP/kg feed dry matter is required, a value considerably in excess of that suggested by ARC (1965). Use of appropriate amounts of two (or more) protein concentratesto ensure the correct protein degradability of the ration as a whole results in a lowered CP requirement compared with ARC (1965) specifications, For the growing/fattening steer ARC (1980) gives a slightly higher requirement for CP concentration in feed dry matter reflected in the increased amount of ureasupplement used,

Brief reference will now be made to some recently, mostly unpublished, data from'the Department of Agricultural Biochemistry and Nutrition, University of Newcastle upon Tyne, which are relevant to the proposed ARC (1980) scheme for protein evaluation,

MICROBIAL N PRODUCTION IN RELATION'TO INTAKE OF DIGESTIBLE ORGANIC MATTER

Table 11 shows some values obtained using dry cows for amounts of microbial N produced and the proportion of the digested OM intake (DOMI) which is apparently digested in the rumen; the data relate to a variety of feeds. It will be recalled that in the ARC (1980) scheme the mean values accepted for these two parameters are 30g/kg OMApDR and 0.65; and which when taken collectively imply that (30 x 0.65)g i.e. 19.5g microbial N enter the small intestine of the animal/kg DOMI. It can be seen from Table 11 that with silages fed alone and with hay/rolled barley diets &supplemented with urea, microbial N yields are generally lower than the value of 30 and the proportion of digested OM intake apparently lost in the reticulo-rumen is somewhat higher than 0.65. The net effect for such diets is to give yields of microbial N (g)/kg DOMI close to the value of 19.5 (see Table 11): Notable exceptions are when a protein supplement was given to feed comprising silage, barley; dairy cake, or when hay/rolled barley diets or alkali-treated straw/barley.

diets were supplemented with IBDU given 3x/d or with urea given "little and often" (i.e. 24x/d). The flaking of barley compared with rolling increased efficiency of microbial N production in the rumen.

TABLE 11 ARC (1980) 'Protein Systems: Some recent data relating to several diets fed to dry cows for microbial N yielded from the reticulo-rumen and proportion of the DOMI apparently digested within the reticulo-rumen

	Microbial N(g) /kg OMApDR** (1)	OMApDR / DOMI (2)	1 x 2 / (30x0.65)**	Source of data
Silage (wilted, no additive)	25.3	0.77	1.00	Overend (1979)
Silage (wilted, no additive)	27.3	0.78	1.09	Brett (1980)
Silage (wilted, no additive)	28.0	0.79	1.13	Brett (1980)
Silage (wilted, formic + formaldehyde)	25.2	0.68	0.88	Overend (1979)
Silage (wilted, formic + formaldehyde) 8.5pt. Silage: soyabean meal 1pt.	31.0	0.73	1.16	Overend (1979)
Silage (wilted, no additive) 1.7pt.: barley, 1pt.: dairy cake 1pt.	27.7	0.78	1.11	Brett *et al.* (1979)
Silage (wilted, no additive) 3.8pt.: barley, 1.3pt.: dairy cake, 2.3pt and soyabean meal 1.0pt.	34.8	0.75	1.34	Brett *et al.* (1979)
Hay 1pt.: rolled barley 2.3pt.	22.4	0.77	0.88	Meggison (1979)
Hay 1pt.: rolled barley 2.3pt. + urea (3x/d)	25.6	0.73	0.96	Meggison (1979)
Hay 1pt.: rolled barley 2.4pt + IBDU (3x/d)	44.6	0.66	1.51	Meggison (1979)
Hay 1pt.: flaked barley 2.4pt.	35.7	0.72	1.32	Meggison (1979)
Hay 1pt.: flaked barley 2.4pt. + urea (3x/d)	33.3	0.70	1.20	Meggison (1979)

TABLE 11 (continued)

Feed	Microbial N(g) /kg OMApDR*	OMApDR DOMI	1 x 2 (30x0.65)**	Source of data
Hay 1pt.: flaked barley 2.4pt. + IBDU (3x/d)	41.0	0.63	1.32	Meggison (1979)
Hay 1pt.: ground maize 3pt.	32.4	0.62	1.03	Meggison (1979)
Hay 1pt.: ground maize 3pt. + urea (2x/d)	29.9	0.67	1.03	Meggison (1979)
Alkali-treated straw 1pt.: ground barley 1pt.	34.7	0.71	1.26	Meggison (1979)
Alkali-treated straw 1pt.: ground barley 1pt. + urea (2x/d)	28.6	0.71	1.04	Meggison (1979)
Alkali-treated straw 1pt.: ground barley 1pt. + urea (24/d)	42.4	0.76	1.65	Meggison (1979)
Alkali-treated straw 1pt. ground barley 1pt. + IBDU (2x/d)	44.4	0.69	1.57	Meggison (1979)

* OMApDR = OM apparently digested in reticulo - rumen
** 30 x 0.65 = microbial N(g)/kg DOMI (ARC, 1980).

IN VIVO DEGRADABILITY VALUES FOR VARIOUS FEED PROTEINS

Some data from the Newcastle laboratory relating to _in vivo_ values 'for the degradability of feed N in the reticulo-rumen of dry cows are shown in Table 12. It must be understood that at the present time there is no one accepted method for determining these values arid, in fact, values derived by each of two methods are shown in the Table for those. diets where the relevant data are to hand.

TABLE Some values for degradability of feed N determined in vivo using dry cows (source of data as shown in Table 11)

Feed	In vivo degrad. of feed N determined on basis of:		ARC (1980) values
	TAA-N*	NA-N**	
Silage (wilted, no additive)	0.88	0.74	0.80
Silage (wilted, no additive)	-	0.69	0.80
Silage (wilted, no additive)		0.77	0.80

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TABLE 12 (continued)

Feed	In vivo degrad. of feed N determined on basis of:		ARC (1980) values
	TAA-N*	NA-N**	
Silage (wilted, formic + formaldehyde)	0.60	0.47	0.30
Silage (wilted, formic + formaldehyde) 8.5pt :soyabean meal 1pt.	0.74	0.77	0.44
Silage (wilted, formic acid + formaldehyde) 1.7pt.:barley 1pt.: dairy cake 1pt.		0.82	0.80
Silage (wilted, formic acid + formaldehyde) 3.8pt.: barley 1.3pt.: dairy cake 2.3pt.: soyabean meal 1.0pt.		0.79	0.80
Hay 1pt.: rolled barley 2.3pt.	0.79	0.75	0.80
Hay 1pt.: rolled barley 2.3pt. + urea (3x/d)	0.85	0.66	0.86
Hay 1pt.: rolled barley 2.4pt + IBDU (3x/d)	0.87	0.75	0.86
Hay 1pt.: flaked barley 2.4pt.	0.79	0.76	0.80
Hay 1pt.: flaked barley 2.4pt. + urea (3x/d)	0.86	0.71	0.87
Hay 1pt.: flaked barley 2.4pt. + IBDU (3x/d)	0.90	0.63	0.86
Hay 1pt.: ground maize 3pt.	0.74	0.39	0.66
Hay 1pt.: ground maize 3pt. + urea (2x/d)	0.81	0.86	0.75
Alkali-treated straw 1pt.: ground barley 1pt.	0.62	0.69	0.80
Alkali-treated straw 1pt.: ground barley 1pt. + urea (2x/d)	0.69	0.72	0.87
Alkali-treated straw 1pt.: ground barley 1pt. + urea (24x/d)	0.78	0.97	0.86
Alkali-treated straw 1pt.: ground barley 1pt. + IBDU (2x/d)	0.79	0.74	0.86

Footnotes over page

TABLE 12 footnotes

$$*\text{determined as } 1 - \left(\frac{\text{total amino acid into S.I. - microbial total amino acid flow into S.I.}}{\text{Total N in feed}} \right)$$

$$**\text{determined as } 1 - \left(\frac{\text{total non ammonia N into S.I. - microbial-N into S.I.}}{\text{Total N in feed}} \right)$$

In one method (designated TAA-N in Table 12) degradability is expressed as 1- (total amino' acid N (TAA-N) entering the small intestine less the microbial TAA-N entering therein, and the difference divided by total N (TN) fed). In the other method, (Designated NA-N in Table 12) values are derived as 1- (total non-ammonia-N (TNA-N) entering the small intestine less the microbial N entering therein, divided by the TN fed). . In the first mentioned only amino acid flowing into the small intestine is considered although error arises since no allowance is made for those amino acids orrurring in the gastric secretions. In the second method, based upon NA-N flow into the small intestine, additional error is associated with any non-ammonia, non amino acid N originating from feed or gastric secretions, which enter the small intestine. We suggest that if data for 'amino acid N flows are available, the first method is the preferred one.

EFFICIENCY OF UTILIZATION OF NON-PROTEIN-N IN CATTLE

Table 13 'shows some values for the efficiency of use of two NPN sources, urea and isobutylidene diurea- (IBDU) in cattle fed basal diets comprising either cereals given individually with hay or alkali-treated straw. Efficiency of NPN use is calculated as the increase in microbial -N (g) entering the small intestine over that observed when no NPN supplement *is* given /kg N in the NPN supplement.

TABLE 13 Efficiency* of NPN utilization (data of' Meggison, McMeniman & Armstrong 1979)

Source of NPN	Frequency of feeding	Basal diet	Efficiency of NPN utilization[1]
Urea	3x/d	hay, barley	-46
Urea	2x/d	alkali-treated straw + barley	-139
Urea	24x/d	alkali-treated straw + barley	786
IBDU	3x/d	hay, barley	875
IBDU	2x/d	alkali-treated straw + barley	746

*Efficiency expressed as increase, over that on basal ration, of microbial N entering small intestine (g)/kgN in NPN supplement.

With urea, efficiency only approached the value of 800 as used by ARC (1980) when it was fed "little and often" i.e. 24x/d. With IBDU - a slow, sustained release source of NPN - efficiency is high even when the NPN product is fed infrequently.

CONCLUDING REMARKS

It can be seen from the data referred to in the later part of the paper, based on in vivo observations obtained in dry cows, that, at the present state of knowledge, the factors proposed for use in the ARC (1980) scheme for protein evaluation provide a reasonable estimate of the amino acid supply to the ruminant. One area where further knowledge is clearly needed is the level of degradability of the crude protein in various feeds. The in vivo method is clearly unsuited for routine laboratory assessment. The dacron bag technique provides a means of ranking feeds in order of their degradabilities as can be seen in the results presented in Table 14. However, the choice of a 24h period is arbitary and the method needs to be combined with a determination of mean retention time of feed particles within the rumen (as distinct from fluid retention time referred to in Table 14) to estimate the actual degradabilities for different feed proteins.

TABLE 14 . Comparison of some. degradability values determined 'in sacco' with values determined in vivo for cattle

Feed	Basal diet for 'in sacco' determination	Values determined 'in sacco' at mean fluid retention time in rumen	Values determined 'in sacco' at 24h	Values determined 'in vivo'	Source of data
Soyabean meal	hay, soyabean meal	0.73	0.96	0.82	Brown/ Overend (1980)
Soyabean meal	hay, barley, soyabean meal	0.41	0.70	0.74	Rooke (1980)
Soyabean meal (HCHO protected)	hay, barley, soyabean meal	0.21	0.31	0.39	Rooke (1980)
Hay	hay	-	0.55	0.62	Brown/ Overend (1980)
Silage	silage	0.82	0.88	0.77	Brett (1980)