MECHANISM OF ACTION OF BYPASS PROTEINS

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SUMMARY

The mode of action of bypass protein as supplements to ruminants is discussed in relation to their effects which may be (i) stimulating feed intake, (ii) increasing microbial growth and activity and therefore efficiency, (iii) increasing the efficiency of utilisation of absorbed nutrients and (iv) providing energy which does not have a "rumen load". 'The effects of bypass proteins on the efficiency of utilisation of absorbed products is also discussed in relation to plasma levels of growth hormone and insulin.

INTRODUCTION

In the previous paper in this symposium it was argued that the responses to "'bypass protein" supplements in cattle and sheep on diets low in true-protein (which are adequate in urea for rumen fermentation) may be due to a variety of attributes of the supplement. In this presentation it is'assumed that any responses in cattle or sheep on such diets to protein supplements can be directly attributed to the supply of amino acids to (i) the rumen microorganisms or (ii) to the animal by bypassing rumen fermentation.

The literature in this area is at present confusing because of the variety of approaches that have been used, the physiological state and the level of production of the experimental animals. A complete literature survey will not be made and the published work which emphasises the concepts which are at present held in this research group are discussed. In this way sufficient controversial hypotheses will be developed to stimulate more research in these areas.

Concern over the differential responses to, and interpretation of, the effects of protein supplementation of cattle and sheep is one occupying most scientists who are active in this field and three excellent papers appeared in a recent Nottingham-Recent Advances in Nutrition - 1980 (Oldham 1980; Hagemeister et al. 1980 and Gordon 1980) which attempted to rationalise the various responses to protein supplementation of dairy cows.

In general, European and N. American researchinto protein nutrition of ruminants has been dominated by studies of the requirements for amino acids for a high level of production (often close to genetic potential). In contrast, with animals on diets with a high proportion of cellulose . or sucrose, the aim of researchers has been to optimise economic production from a diet by using supplements to increase intake of the basal diet (see Preston and Leng 1980; Leng et al. 1977). In the latter approach, the optimum production is often well below genetic potentialof the animals. Even an expensive supplement which, in small amounts, stimulates feed intake can be used highly efficiently.

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In the future, ruminant systems should be based on dietary materials which require fermentation. In these feeding systems the concentrates should be used to stimulate maximum use of the low cost (and low 'quality for monogastric animals) feed. Under these circumstances the concentrates are used with maximum efficiency and as supplements for ruminants are often more. efficiently used than when they are fed to pigs and poultry. The rational use of supplements requires knowledge of the mode of action of supplements and the site and mode of action of bypass protein meals is discussed below.

EFFECTS IN THE ANIMAL OF BYPASS PROTEIN SUPPLEMENTATION

On the cellulose or cellulose/sugar based diets it was recognised early that a major effect of providing more amino acids for absorption by the animal resulted in increases in feed intake and that this effect made the major contribution to any increased production (see Preston, 1972; Kempton and Leng 1979; Kempton 1981). Ørskov et al. 1973 also showed an increased intake of a basal diet by lambs on crushed barley given a fish protein concentrate by suckling (which delivered this to the abomasum directly). In experiments covering a range of diets for cattle and sheep, the major effect of supplying protein meals has been to increase feed intake. In some experiments however, feed intake has not changed and the response to protein meals can be directly attributed to the extra energy and/or amino acids in the supplement.

Recently Oldham et al (1979) have postulated an effect of protein as such on digestion of concentrate, diets, and in addition that amino acids absorbed from the lower digestive tract increase growth hormone levels in plasma resulting in increased efficiency of utilisation of. absorbed nutrients.

Thus the postulated effects of bypass proteins are:

(1) stimulating feed intake
(2) influencing the efficiency of microbial cell yield and digestion
(3) influencing the partitioning'of absorbed nutrients for production
(4) providing amino acids post ruminally which are used efficiently, and in addition increasing the total energy intake.

Except for (4.) above the responses to protein supplementation result from quite small amounts of materials and suggest a "catalytic role" for protein meals.

Stimulation of feed intake by bypass protein

The effect of protein supplements on 'feed intake is summarised as follows: on diets low in true protein, feed intake is generally stimulated by feeding bypass protein. That this is also true for grain based. diets is indicated by the studies of Clay and Satter 1979 (Fig. 1 after Oldham 1980) and Ørskov et al (1973) (Table 1).

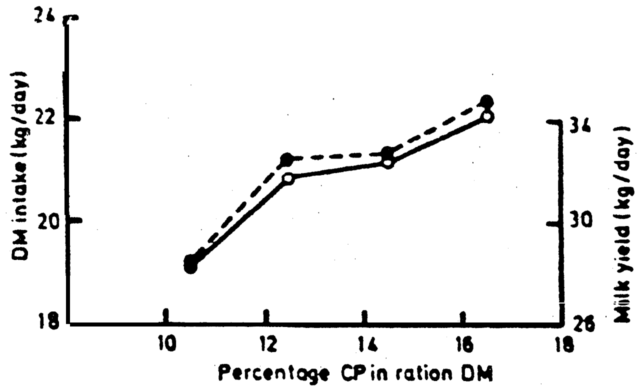

Fig. 1 The effect of increasing the percentage crude protein in ration dry matter on milk yield (•) and feed intake (o) in cows (data from Clay and Satter (1979) as modified by Oldham (1980)).

TABLE 1 Daily intake of basal feed at various live weights by lambs receiving no supplement or given urea or increments of fish-protein concentrate (FPC) in solution by bottle so that the rumen is bypassed (Ørskov _et al_. 1973)

Supplement (g/d)	Intake (g dry matter/d) 25 kg live wt	35 kg live wt	45 kg live wt
None	851	1078	1265
10 urea	853	1062	1246
17 FPC	994	1190	1415
34 FPC	927	1196	1561
51 FPC	1003	1241	1416

(each value is the mean of four animals)

Influence of bypass protein on microbial protein production

If the supply of relatively insoluble proteins increases microbial growth in the rumen and also provides extra essential amino acids to the animal, the'sometimes large effect of bypass protein can be explained. However a protein that is too soluble would result in loss of dietary protein by fermentation which may be compensated for by the protein that escapes rumen fermentation and the possible increased microbial growth.

The research on which the suggestion that slow release amino acids affects microbial growth is based is as yet rather tentative. Maeng _et al_. (1976) using washed rumen organisms showed an increased microbial yield _in vitro_ when amino acids provided the major N sourceand Oldham _et al_. (1979) found an increased digestibility of a concentrate/roughage diet by dairy heifers fed at maintenance when fishmeal replaced urea in the diet (see Table 2). The same diets fed _ad lib_ to dairy cows resulted in 12% increase in milk yield when some fishmeal was included in the diet as compared to supplying all the extra N as urea.

TABLE 2 Milk yield and milk protein output of cows given 20 kg silage, 2 kg alkali-treated wheat straw and 11.5 kg concentrates. Digestibility of the same diet fed at maintenance to heifers (Oldham 1980)

Treatment	Cows			Heifers*
	Milk Production		Liveweight change (g/d)	O.M. digest (%)
	Volume (1/d)	Protein (g/d)		
Urea (288 g/d)	26.1	785	+370	0.73
U + Fishmeal	29.4	894	+530	0.78
F + Urea	28.4	888	+180	0.80
Fishmeal	28.1	848	+130	0.83

*Heifers were fed at maintenance

The results in Table 2 are rather difficult to explain however, since it is difficult to reconcile the lower production when fishmeal was used without urea as compared to the urea treatment since the ammonia concentration in the rumen were always well above the minimum of 50 mgN/1 and, there was considerable soluble N already in the diet before the addition of an extra 280 g urea in the urea treatment group.

The efficiency of microbial growth is unlikely to affect the digestibility of starch in the rumen since the starch energy will either be converted to VFA or microbial cells and the efficiency of microbial, growth is only a function of the balance between the two. A lower digestion in the rumen of this diet when supplemented with urea alone should potentially increase the availability of starch for direct digestion or absorption in 'the small intestine. However, if the lowered overall digestion is due to a reduced digestion of the fibre of silage in the rumen, this should be compensated for by fermentation in the caecum. The results suggest there was a problem created by feeding a large amount of urea (280 g/d) in addition to an already high N intake (about 1870 g CP/day) rather than a specific stimulating effect of amino acids on microbial growth. A further problem with this study is that there was no controls without supplement.

On sugar based diets the supply of large amounts of soluble proteins has not apparently affected microbial growth, which has-been extremely high compared with that estimated on starch based diets (see Elliott et al. 1978; Kempton et al. 1981) (see Leng 1981). There is also no indication of an increased microbial growth or an increased digestibility with bypass proteins on cellulose based diets (Kempton et al 1979).

Other considerations

The effect of the N source on the composition of the microbial community developed in the rumen has not been extensively studied, but one, of the major factors that may influence the practical application of the above results is that in studies of microbial protein production, animals are fed at a constant rate which probably markedly changes the microbial communities present. On starch based diets in particular, constant feeding of concentrates may increase protozoal numbers from virtually nil in animals fed once' per day to biomasses which' suggest that 50-70% of the microbial biomass is protozoa (see Leng 1976). The slow release of protozoa from the rumen (Weller and Pilgrim 1974; Leng et al. 1981; Leng . 1981) together with their feeding on bacteria (Coleman 1975) and apparent death and lysis in the rumen (Leng 1981, unpublished observation) leads to at least 20% decrease in microbial protein passing from the rumen (Lindsay and Hogan 1972) which results in lower wool growth (milk production?) (Bird et al. 1979) and, at low protein concentrations in the diet a lowered growth rate (Bird and Leng 1978).

Protozoa1 biomass should be monitored in all studies of the effects of bypass proteins in nutrition to demonstrate whether these are affected by treatment. Unfortunately protozoa1 counts do not necessarily indicate biomass because of (i) the inability to sample the protozoa1 pook, (ii) the differential sizes of protozoa and (iii) their different turnover rates in the rumen (Leng 1981). It will be necessary where there appears to be a change in the protozoa1 pool, to monitor protozoa1 pool size using isotope dilution procedures such as those suggested by Coleman et al. (1980) and developed in these laboratories (Leng et al. 1981).

Influence of bypass protein on the partitioning of nutrients and their efficiency of use .

There are' now a number of publications which indicate that there is an increase in the efficiency of utilisation of absorbed nutrients in ruminants when concentrate/roughage diets are supplemented with bypass protein. In the studies of Ørskov et al. (1973) there appears to be an increased efficiency of utilisation of metabolisable energy in lambs given crushed barley and fishmeal. Raising the level of fish protein concentrate given via suckling from 34 to 51 g/d to lambs on this diet apparently . improved feed conversion from 3.22 to 3.03 kg DM/kg gain without any effect on total feed intake. Since the fishmeal bypassed the rumen the effects on digestibility postulated by Oldham et al. (1979) cannot explain 'this apparent increased efficiency. Gordon (1980) reported results in which extra protein stimulated intake of silage and increased milk production markedly but the effects could not be attributed entirely to the increased intake of protein and silage and suggested an increased efficiency of utilsation of absorbed nutrients.

The effects of growth hormone (GH) have been examined in growing lambs (25-35 kg body weight) fed a diet based on oaten chaff/sugar together with NPN or NPN plus bypass protein, in which plasma GH levels were manipulated by immunological approaches (e.g. immunization against growth hormone release inhibiting factor - SRIF). In the particular animals used for the study, overall production was low (group mean daily liveweight gain of 103 to 124 g/day) and there was no effect of bypass' protein on feed intake (which is usually repeatable) in both control and treatment groups.

Plasma insulin and GH profiles were determined and although GH levels were increased (with no effect on insulin levels) in the groups immunized against SRIF, there was no apparent effect on growth. However, within groups there was considerable between animal variation in hormone status (both for insulin and GH) and productive parameters. From the pooled data there was no relationship between feed intake and hormonal status but there was a highly significant ($P<0.001$) relationship between mean plasma insulin and feed'conversion efficiency over the period of study (Fig. 2). The most efficient lambs had the highest mean plasma insulin 'levels.

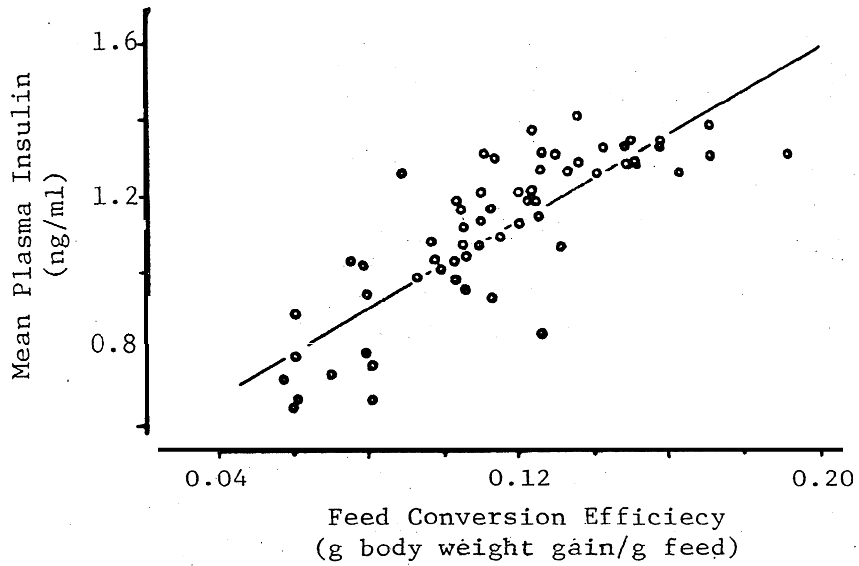

Fig. 2 The relationship between mean plasma insulin level and feed conversion efficiency in growing lambs.

The lack of relationship between mean plasma hormone concentrations' and-feed intake is at variance with the report of Bassett et al. (1971) which showed significant relationships between plasma hormone status (both insulin and GH) and feed intake parameters (DOM intake and NAN intake) for mature merino wethers fed ad lib on a range of forage diets. This disagreement is not surprising for two reasons: (1) in the present study ad lib intake by the young' animals was over a limited range (calculated: 450-850 g DOM/day) whereas in the above mentioned study intakes were from 0 to 970 g DOM/day; (2) the different physiological states involved and therefore different homeostatic and homeorhetic mechanisms may operate (see Bauman and Currie 1980).

The finding of a significant relationship between plasma insulin and feed conversion efficiency is in agreement with the concept that insulin is a major regulator of energy metabolism and probably of general anabolic metabolism in ruminants (Bassett 1978). Furthermore, it emphasises the role of glucose as a potential central controlling mechanism for production in ruminants asindicated by the studies showing a high correlation between glucose synthesis rate and both plasma insulin and growth rate in sheep and cattle (Leng 1970; Bassett et al. 1971; Leng et al. 1977). Bassett (1975) has suggested that insulin release may be regulated by amino acid absorption from the small intestine of sheep.

If there is a high correlation between feed conversion efficiency and insulin status, plasma insulin levels at a given feed intake may allow early selection of the more efficient animals.

CONCLUSIONS

There is a need for further research into the effects of amino acids or NPN on the rate of microbial cell synthesis in the rumen. The effects of increased absorption of amino acids are complex and inter-related., and a great deal of research is needed on intake and production to explain the responses (or lack of) to bypass proteins in a wide variety of situations. In particular attention should be given to studying insulin secretion (and by implication glucagon) which appears to be 'involved in promoting efficient utilisation of absorbed nutrients.

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