

3.4. FEEDING OF BYPASS NUTRIENTS TO RUMINANTS

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INTRODUCTION

The term "Bypass Nutrient" refers to that fraction of the nutrients which gets fermented in the rumen to a comparatively low degree. It then becomes available at the lower part of the gastro-intestinal tract in the intact form for subsequent digestion and absorption. These slowly degradable proteins also have a function to provide the rumen microbes with a steady supply of nutrients, rather than with sudden bursts from easily soluble nutrients. These concepts were introduced in the early eighties, primarily to replace the conventional digestible crude protein system which has many limitations. They describe the protein quality of a feedstuff for ruminants, and the protein requirements based on rumen degradable protein (RDP) and undegradable dietary protein (UDP). Subsequently, the term has been extended to other nutrients like carbohydrates and fats that could also escape rumen fermentation partially, to be digested in and absorbed from the small intestines. The new approach envisages minimisation of ruminal fermentation losses, and better utilisation of the nutrients after their digestion and absorption from the small intestines. This paper discusses the new approach

for conditions in India and other countries, where quality feed resources are available in limited quantities, and where cereal straws form a major source of roughage.

THEORETICAL CONSIDERATIONS ABOUT SLOWLY DEGRADABLE NUTRIENTS

There are three type of nutrients that could bypass rumen fermentation to certain degree:

- protein/amino acids,
- starch/glucose,
- fats/fatty acids,

Minerals (Zn, Cn, Mn) can be chelated, but in that form they entirely bypass the rumen, as they are stable at ruminal and abomasal pH.

The slowly degradable or "bypass" nutrients may occur in feeds in their natural form, but feeds can also be manipulated to restrict their degradation in the rumen. Nutrients should be made resistant to microbial enzymes to such an extent so that rumen microorganisms get sufficient nutrients for efficient rumen functioning with respect to fibre digestion and microbial protein synthesis.

The purpose of feeding "bypass" protein is that a large proportion of the protein is available directly at the lower part of gastro-intestinal tract, where it is digested and then absorbed as amino acids for utilisation at tissue level. Feeding of "bypass" starch reduces excess production of lactic acid in the

rumen which would otherwise result in low rumen pH (acidosis), thereby affecting fibre digestion. Feeding of "bypass" fat (protected fat) is done primarily to avoid ruminal hydrolysis of bio-hydrogenation of unsaturated fatty acids and increasing energy density of feeds. The fats are thus digested mostly in the small intestines and absorbed as unsaturated fatty acids without affecting the fermentation of fibrous feeds in the rumen.

METHODS OF MAKING BYPASS NUTRIENTS

Some nutrients have bypass characteristics in their natural forms. However, others are required to be manipulated to reduce their rumen degradability for optimisations of ratios between degradable and undegradable nutrients in the diet.

Protection of proteins

The main methods available to protect proteins are the use of chemical reagents or heat treatment. In the past, formaldehyde was used (applied @ 1.2 g/100 g CP) to reduce the degradability of highly degradable proteins in rumen. However, its corrosive nature and possible carcinogenic effect had prevented it to be used as an agent for protection of proteins. Recently a group of Australian workers, however, have demonstrated that formaldehyde is metabolised to CO₂ and water after its absorption from intestines, thus reducing the fear for carcinogenic effects.

Other technologies for inhibiting protein degradation in the rumen include the treatment with metal ions (ZnCl₂ and ZnSO₄), coating with insoluble protein (blood, zein), acid and alkali treatment (NaOH, HCl, propionic

acid), alcohol (ethanol) treatment and acetylation of peptides (acetic anhydride). But, to-date none of these have been commercialised. With regard to heat treatment, the temperature and the period of treatment is critical. If this combination is not proper, the protein is either under protected or over protected. Heat treatment of groundnut cake and soybean meal at 150°C for two hours seems to give sufficient protection. However, such a processing may not be economically feasible due to the high cost of equipment and energy. During the solvent extraction of oil cakes, the temperature reaches only 90-95°C and the proteins are only partially protected at this temperature.

Protection of carbohydrates

Protection of starch can be achieved with formaldehyde treatment. Ammonia treatment could be another effective method to protect starch from ruminal hydrolysis. Treating starch with sodium carbonate plus sodium hexameta phosphate has been demonstrated to reduce starch degradation in the rumen.

Protection of fats

Lipids encapsulated by formaldehyde treated protein is an effective method of protection against ruminal hydrolysis and bio-hydrogenation of lipids, but due to the use of formaldehyde, the method has its limitation. During the refining of edible oils, free fatty acids are removed by treating with sodium hydroxide and then with acid. The free fatty acids thus removed by centrifugation are termed as acid oil which has roughly one-third the price

of edible oils. These acid oils can be converted into calcium salts either by fusion or participation method. Thus, the fatty acids in the form of calcium salts are protected against the rumen enzymes, a method that can be commercially used for the protection of lipids.

NATURALLY OCCURRING BYPASS NUTRIENTS

In some feedstuffs, nutrients are naturally bound to other feed components, thus reducing their rumen degradability. The bonds with which the nutrients are linked remain intact in the neutral environment (pH = 6-7) of the rumen, but they are broken in the acidic environment of the abomasum (pH 2-3). These are referred to as naturally occurring bypass nutrients. Bypass protein values for some of the commonly used feedstuffs are given in Table 1. The feeds with higher bypass protein values are: cottonseed cake, maize gluten meal, coconut meal, fishmeal and leaf meals like *Leucaena leucocephala* (subabul). Similarly, the fermentation of starch from maize in the rumen is limited, thus, it is good source of bypass starch. With regard to fats, when fed through oilseeds, they are partially degradable in the rumen.

METHODS TO EVALUATE THE EXTENT OF PROTECTION

Whether the nutrients are naturally or artificially protected, there is a need to measure the extent of protection, i.e. the extent of degradation/hydrolysis in the rumen. For proteins, the rumen degradability by nylon bag technique is widely used. Values of effective degradability from different regions are available in India from published papers (Table 1). From these, the RDP and

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UDP values can be calculated for feeds. ARC (1984) and NRC (1985) have given the requirements for these two protein fractions in dietary protection for ruminants with respect to growth and milk production. For starch, limited work has been carried out so far. Those who have worked to measure the degree of protection, have done so by way of using labelled glucose and measuring glucose uptake at the intestinal level. With regard to fats, the percent of unsaponified or free fat can be found out by extraction with petroleum ether. The unsaponified fat gives degree of protection. The major problem in the measurement of degradation rate is that it indicates degradation for a given time. Since, it is not always clear how fast the feed passes the rumen, it remains difficult to estimate the actual fraction that leaves the rumen undegraded.

PRACTICAL IMPLICATIONS OF FEEDING BYPASS NUTRIENTS

Theoretically speaking, there appears to be good reasons to feed bypass nutrients for increased efficiency of nutrient utilisation by ruminants, especially at higher production levels. In practice, however, the animals' response is quite variable. In the case of lactating ruminants, the response depends on several factors, such as:

- physiological status;
- stage of lactation;
- level of production;
- body condition score;
- availability of other nutrients.

Table 1. Undegradable dietary problem (UDP) in feedstuffs (g/100 g CP).

	Feedstuffs of high UDP (60-100% of CP)	Feedstuffs of medium UDP (30-59% of CP)	Feedstuffs of low UDP (0-29% of CP)
Bajra (pearl millet)		68 Brewers grain	53 (48-61) Barley
Blood meal		79 (76-81) Canola meal	31 (26-37) Exp. Proc. Coconut cake
Sol. extr. coconut cake		76 (70-81) Corn ground	41 (31-52) Ginglyly cake
Coffee seed cake		82 Cotton seed cake	49 (35-70) Gram Chuni
Corn grain, cracked		81 (71-87) Fish meal	59 (40-70) Lupin meal
Feather meal		84 (83-86) Groundnut cake	32 (6-38) Niger cake
Fescue pasture		72 Horse gram	43 Oats, grain
Mahuva seed cake		75 Karanja cake	47 Rape seed cake
Meat meal		61 (53-76) Linseed meal	35 (11-45) Silk cotton seed cake
Rice bran		62 Meat and bone meal	53 (49-70) Sunflower cake
Sorghum grain		75 Mesta seed cake	43 Wheat grain
Alfalfa, dehydrated		60 (57-69) Rubber seed cake	31 Wheat bran
Subabul (<u>Leucaena Leucocephala</u>)		68 (51-75) Ricebran, deoiled	56 Alfalfa, fresh
		Safflower cake	39 Alfalfa, silage
		Soyabean meal	34 (10-50) Barley silage
		Tobacco seed cake	57 Corn silage
		Toria seed cake	57
		Alfalfa hay	33 (22-43)
		Cornfodder, fresh	41
		Cow pea fodder	32
		Guineagrass	60
		Oats fodder, fresh	49
		Para grass, fresh	52
			18 (11-27)
			28
			24 (10-43)
			18
			24
			19 (16-23)
			18 (14-20)
			25 (10-46)
			22
			15
			25 (20-36)
			27 (23-33)
			24 (21-27)
			23
			18
			24 (11-31)

Responses are likely to be more favourable in high yielding animals in the early part of lactation or fast growing animals. These are typical situations where the demand for nutrients is high and where the animal may be in negative protein and energy balance with lower body condition score.

Feeding bypass protein

Generally, straws are poor in protein and minerals, but rich in cellwalls which are degraded in the rumen only through microbial fermentation. Feeding of slowly degrading nutrients along with straw provides ammonia and to some extent minerals which might improve fibre digestion.?

The net result of feeding bypass protein could be the enhanced supply of amino acids from the intestines available for absorption and the overall improvement in the utilisation of dietary proteins. Some of the work done on bypass protein in India is given in Box 1.

The achieved positive responses in gain, reproduction and milk yield to feeding bypass nutrients should be interpreted with caution. In many instances, much of the responses achieved could be explained to the supply of other nutrients (such as energy or critical minerals like P and S) rather than to the supply of bypass nutrients. This is more so when the basal diet is deficient or has limited supply of energy. Also, due to the slower release of nutrients in bypass feeds, the rumen function can be more stable.

Feeding bypass starch

Feeding of bypass starch can reduce excess production of lactic acid in rumen, which otherwise inhibits fibre digestion due to acidic pH condition

in the rumen. Thus, starch which escapes rumen fermentation, is digested in the small intestines producing glucose, which after absorption is more efficiently used as energy source by the animals, compared to lactic/propionic acid absorbed from rumen.

Box 1. Some animal production responses to feeding of bypass nutrients.

Growth responses to the feeding of bypass proteins have been positive in some trials. At Karnal, feeding of formaldehyde treated GN cake and soybean cake gave significant increases (up to 100-150 g/d) in liveweight gain, while the combination of ammoniated straw and bypass protein produced the highest growth rate in calves. The feed conversion (kg feed/kg live weight gain) for growth was highest with untreated straw supplemented with bypass protein. Another positive aspect attributed to feeding of bypass protein, appears to be the increased reproductive efficiency in both male and female ruminants. Whether this is a secondary effect due to improved health of the animal, or whether it is directly due to bypass nutrients remains to be determined.

In a recent study in Karnal, maize gluten meal and cottonseed meal supplementation to provide 60% bypass protein gave significantly higher (1.5 kg/d) milk yield over the supplementation providing 50% bypass protein in lactating crossbred cows, yielding between 10-15 l of milk/d. Similarly, when all the nitrogen from GN cake in the concentrate was replaced by leucaena leaf meal, lactating goats yielded more milk than control.

Feeding bypass fats

Feeding of protected fats, mostly as calcium salts of fatty acids can increase milk yields and also the efficiency of energy utilisation in high yielding animals that receive diets of too low energy content. Although in many parts of India, the supply of energy feeds for ruminants is limited, normally it may not pose an acute problem because many cows are low yielders. However, it is difficult to meet the energy requirement of high yielding cows, especially in early lactation as the dry matter intake increases few weeks after the cows have attained peak yield. During 2 to 3 months, high

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yielding cows can be fed bypass fat. The minimum dietary fat level should be 3 percent in high yielding cows. However, in countries where animals are fed primarily on crop residues, feeding of bypass fat could help increasing milk production and growth. Inclusion of fats in the diet (more than 4-5%) generally causes disturbance in rumen fermentation, mainly through inhibition of fibre digestion. However, the inclusion of protected fats in ruminant diet can cause increase in the energy density of the diet without causing any reduction in fibre digestion in rumen.

In developing countries, where cost of fatty acids (fat) is very high, acid oils can be converted into calcium salts and fed which are otherwise toxic to the rumen microflora. However, under those situations where feeding fat is not cost prohibitive and is to be fed more than 5 percent in the diet, fat can be again fed in the form of calcium salts without affecting ruminal fermentation.

CONCLUSION

In general, feeding of bypass nutrients may prove beneficial for past growing calves and high yielding dairy animals as they have greater demand of nutrients. The animal response may be, however, quite variable due to other limiting factors (nutrients, health, management) affecting the utilisation of nutrients. The positive response to bypass protein feeding at lower levels of production may be partly attributed to the supply of energy through these diets. This is particularly so when supplements containing bypass nutrients are fed together with low quality fibrous feeds such as straws.

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