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Bypass protein technology: A review

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Abstract
Feeding accounts for a major portion of the costs incurred on milk production. Imbalanced ration and scarcity of feed are two of the many factors limiting the productivity of dairy animals. The inefficient utilization of expensive feed resources, especially proteins adds to the cost of milk production. The fermentation of proteins in the rumen before enzymatic digestion results in lower efficiency in utilization of proteins. High yielding animals require higher proportion of nutrients in the diet that bypass the rumen without degradation to supply the necessary amino acids at the intestinal level. Bypass proteins may be provided in the diet of ruminants through feed ingredients containing proteins with a higher bypass value. Alternatively, physical or chemical treatment of protein sources which contain low bypass value. Protected protein supplements must provide roughly 70% of the protein in undegradable form. Eighty percent of the un-degradable protein must be digestible in the intestine of the animals. Bypass feed technology is particularly relevant to the animals reared in tropical climate. It is a relatively cheap method of providing high quality protein for animals, increases the availability of essential amino acids in diet, improves milk production, improves fat and SNF percentage in milk and improves the growth of young animals.

Keywords: Bypass protein, ruminants, milk, undegradable intake protein

Introduction
Appropriate feeding of dairy cattle is of prime importance as feed costs account for more than half of the total costs of milk production (Jimmy *et al*., 1980) [13]. Shortages of feed and imbalanced nutrition are major constraints to livestock productivity. Despite fodder and feed shortage, there is tremendous scope to improve productivity of dairy animals with existing resources by addressing the issue of imbalanced ration. A balanced ration must provide adequate quantities of energy, protein, minerals and vitamins from green fodder, dry fodder, concentrates and mineral mixtures etc. for optimum production and health (FAO, 2012) [9]. Protein feeds being expensive and scarce, the existing protein resources must be used judiciously (Garg, 2009) [11].

Bypass proteins have been suggested as an efficient method of improving the protein availability in the diet of dairy animals. It is seen as a sustainable approach to increase the yield of dairy cattle by improving the nutrients from the available sources of proteins. The technology of bypass proteins is being discussed with focus on the protein digestion process in dairy animals, natural sources of bypass proteins and the commercial production of bypass proteins.

Protein Digestion in Ruminants
Proteins are biological polymers of amino acids linked together by amide links also called peptide bonds. Proteins contain about 16% nitrogen. The dietary protein for ruminants refers to Crude Protein (CP) which consists of protein component as well as Non-Protein Nitrogen (NRC, 2012) [20]. Proteins are a source of amino acids to all living beings. The amino acids generated from proteins are used for maintenance, growth, reproduction and during milk production in the udder.

Crude protein in ruminant diet can be divided into two categories based on its degradability during fermentation:

a. Degradable intake protein (DIP)
b. Undegradable intake protein (UIP)

Rumen microflora breaks the DIP component into amino acids, peptides and ammonia (NH3). Ammonia is used partly by the microorganisms along with some amino acids and peptides. The rest of ammonia escapes through rumen wall into circulation.

It is converted into urea in the kidneys. A part of urea enters into circulation and then saliva while the major part is excreted out. UIP or bypass protein passes undegraded into the abomasum and intestine. Along with UIP, some microorganisms also pass out of the rumen into abomasum during rumen contractions. These microorganisms are also digested along with the UIP component acting as a protein source for the animal.

Stern *et al.* (2006) [25] reported that microbial protein synthesized in the rumen accounts for 50 to 80% of the total absorbable protein supplied to the small intestine of the ruminants. It was further reported that although microbial protein alone may be sufficient for low producing ruminants, it may prove inadequate to support higher levels of milk production. With increase in production, additional proteins must be provided in diet that passes the rumen undegraded to meet the protein requirement of the animal.

The utilization of dietary protein in ruminants is low as the digestion of proteins in ruminants involves fermentation in the rumen before the enzymatic digestion (Satter and Roffler, 1975) [23]. Degradability of proteins in rumen affects the quantity of amino acids reaching the intestine (Folman *et al*., 1981) [10]. Overall, microbial degradation causes a depletion of the biological value of high quality proteins (Garg, 2009) [11]. Chalupa (1975) [7] suggested that a beneficial approach would be to utilize non-protein nitrogen for rumen protein production, maximizing bypass protein component in diet and supplementing with rumen non-degradable amino acids. Similarly, Preston and Leng (1987) recommended that feeding strategy for ruminants must focus on improved rumen fermentation process to extract maximum nutrients from forage based feeds and supplementing the diet with nutrients which bypass the rumen to intestine to provide the most favourable balance of nutrient absorption.

Degradation of Proteins in Rumen

According to Bach *et al.* (2005) [3] microbial protein degradation in rumen is primarily dependent on the type of protein, interactions with other nutrients and predominance of microbial population. Orskov and McDonald (1979) [21] suggested that protein degradation and passage rate of proteins through rumen are inversely related. Romagnalo *et al.* (1994) reviewed that insoluble proteins are slowly degraded in the rumen than soluble proteins. Further it was reported that the degradability of protein in the rumen may be associated with the degree of hydrophobicity. The presence of disulphide bonds in soluble albumin renders them slow to degrade (Schwingel and Bates, 1996) [24]. Yang and Russell (1992) [30] demonstrated that certain dipeptides are slowly degraded than others.

Another factor affecting protein degradation is the predominant microbial population which depends further on the substrate being fed and the rumen pH (Lana *et al*., 1998; Cardozo *et al*., 2000; 2002) [15, 5, 6]. Leng (1989) [16] noted that increase in protein to energy ratio can improve the efficiency of nutrient utilization leading to increased production. A well balanced diet containing high energy leads to more rumen microbe production which contributes to greater availability of rumen bypass protein (Moran J, 2005) [18]

Bypass Protein/ Rumen Protected Protein

Some of the common protected nutrients used for the supplementation of ruminant diet are:

Protected Protein,

Protected fat,

Protected starch,

Chelated minerals and vitamins.

The Association of American Feed Control Officials defines "rumen protected" as "a nutrient(s) fed in such a form that provides an increase in the flow of that nutrient(s), unchanged, to the abomasum, yet is available to the intestine." (Noel 2000) [19]. Protected nutrition technology is a feed management strategy involving passive manipulation of rumen to protect the nutrients against hydrolysis to aid their digestion and absorption from the lower tract.

According to Garg (2009) [11], attempts to find methods to protect soluble high quality proteins in diet against microbial degradation began after McDonald (1948) [17] discovered that soluble proteins in diet are degraded to ammonia in the rumen and the observations that post-ruminal administration of proteins or amino acids resulted in greater nitrogen retention compared to direct administration in rumen. Characteristics considered desirable for protected protein supplements (NDDB Portal):

High level of crude protein.

Optimal profile of essential amino acids.

About 70-75 per cent of the protein should be in rumen un-degradable form (UDP).

Approximately 80 per cent of the rumen un-degradable protein should be digestible in the small intestine.

Stock *et al.* (1984) [26] have categorized proteins on the basis of their bypass percentage into four categories as: 1) High bypass proteins (slow degradability), 2) intermediate bypass proteins, 3) low bypass proteins, 4) rapidly degradable proteins

Table 1: Bypass value of various sources of protein

Category	Bypass value	Protein source
High bypass	60- 80%	Blood meal
		Meat meal
		Fish meal
		Corn gluteal meal
		Brewers grain
		Distillers grain
		Dehydrated alfa alfa 20% protein
Intermediate bypass	30- 60%	Dehydrated alfa alfa 17% protein
		Cottonseed meal
		Linseed meal
Low bypass	10- 30%	Soybean meal
		Alfa-alfa
		Corn gluten feed

		Peanut meal Sunflower meal
		Safflower meal
		Rapeseed meal
		Feather meal
Rapidly degradable	0- 10%	Casein
		Whey
		Steep liquor
		Distiller solubles

Protection of Ruminal Degradable Proteins

Chalupa (1975) [7] suggested that protein and amino acid degradation in the rumen can be decreased by heat treatment, chemical treatment, use of amino acid analogues, encapsulation, selective manipulation of balances of rumen metabolic pathways and oesophageal groove closure and use of tannins, and aldehydes. Beever and Thompson (1981) [4] suggested that pelleting, steam rolling or flaking can denature feed protein, thus protecting the protein against lysis in the rumen. Assoumani *et al.* (1992) [1] demonstrated that starch intrudes with the degradation of protein. It was found that addition of Amylases to cereal grains increased the total ruminal protein degradation. Similar results have been reported by Aufrere and Cartailler (1988).

Effect of Feeding Bypass Protein on Milk Yield

Under tropical conditions, bypass proteins can be fed even to the medium producing animals to increase their productivity (Walli TK, 2005) [29]. Tiwari *et al.* (2018) [27] reported that protein supplement with high bypass value may be considered to increase the milk production of high yielding cows in early lactation when basal diet is poor in nutritive value. Vahora *et al.* (2012) [28] reported a higher milk yield in buffaloes fed with formaldehyde treated protein meal. It led to an increase in the yield of 6% Fat Corrected Milk (FCM).

Chandrasekharaiah *et al.* (2008) [8] compared the effect of feeding a concentrate mixture containing 37% CP as bypass protein (in experimental group) and concentrate mix containing 50% CP as bypass protein in cows yielding 8-10 litres of milk per day. The animals in experimental group recorded an increase of 1.07 litres of milk per day with a significant increase in fat, SNF and total solids. Whereas the feed costs were reduced, the income of the farmers increased.

Kunju *et al.* (1992) [14] observed an increase in daily milk production of the order of 1.2 kg per kg of bypass protein in animals fed with bypass protein over those fed with Urea Molasses Block (UMB). The amount of straw was fixed. However, the animals lost body weight of the order of 80-120 gram per day. Increase in body weight and milk production was observed on further addition of bypass protein feed. The maximum response was observed at 3 kg of bypass protein feed per animal per day.

Advantages

National Dairy Development Board (India) has listed the following advantages of feeding bypass protein to ruminants:

a. Relatively cheap source of protein for animals
b. Availability of essential amino acids is increased
c. Improves milk production
d. Improves fat and SNF percent
e. Improved growth of young animals
f. Improvement in reproduction efficiency
g. When used with cattle feed, it helps to control Salmonella and reduces mould growth

Conclusions

Balanced ration providing an adequate mix of energy, proteins, minerals and vitamins is of prime importance to dairy cattle. Feed costs account for majority of the costs incurred at the dairy farm. Shortages of feed and imbalanced nutrition are major constraints to livestock productivity. However, there remains tremendous scope to improve the production levels of the dairy animals even with the existing resources. It calls for a sustainable use of feeds and fodders and an improved efficiency of nutrient availability. Bypass feed technology has been suggested as one such intervention to improve the efficiency of dairy cattle nutrition.

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