Protected Nutrients Technology and its Impact of Feeding to Dairy Animals

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1. Introduction

Livestock production contributes significantly to rural economy and could be cash crops in many small holder mixed farming systems. In tropical countries, there is horizontal growth in terms of animal numbers and now needs to achieve vertical growth in terms of improving productivity, so that future demand of milk would be meet. This can be achieved, if the early lactating high yielding and genetically improved cows and buffaloes were fed according to the nutrient requirement with high energy diet. In tropical countries, the majority of livestock subsist on poor quality native grasses, crop residues and agro-industrial byproducts. Therefore, high yielding and genetically improved dairy animals has big challenge to provide the essential nutrients for meeting metabolic requirements and sustaining milk production. Milk yield and optimum reproductive performance are the most important factors in determining profitability of dairy animals and high milk production is always more important for high profitability than the low feeding cost. In early lactating cows and buffaloes, the energy intake through ration doesn't meet the requirement for higher milk production, resulting in a Negative Energy Balance (NEB), which is closely related to reproductive performance (Shelke *et al.*, 2011). Therefore, minimizing the extent and duration of NEB could be beneficial for reproduction besides getting the best productive performance from cows (Tyagi *et al.*, 2010).

Deleterious effect of NEB on productive performance of early lactating animals would be reduced by supplementation of protected fat in the ration through enhancing energy intake (Remppis et al., 2011). Earlier, supplementation of protected fat was considered only as energy source during the transition period leading to improvement in reproductive performance but later it was demonstrated that the added fat includes improved conception rate, increased pregnancy rate and reduced service period (Silvestre et al., 2011). Reported improvement from protected protein feeding to lactating animals leads to proportionate increase in the supply of amino acids to the host ruminant for productive/ reproductive purpose, with an overall increase in the efficiency of protein and energy utilization. A series of trials have been conducted on cattle and buffaloes on feeding of protected protein, to see its effect on growth and milk production. The average growth rate and milk production was increased by 15-25 and 10-15%, respectively

(Shelke *et al.,* 2011). Various studies showed that, formaldehyde treatment was efficient and cheaper method to protect the protein source from highly degradable cakes in the rumen (Walli, 2005) and its feeding significantly increased daily milk yield and protein, fat, SNF, total solids content of milk (Chatterjee and Walli, 2003). The technology of feeding formaldehyde treated cakes has been adopted in India by some milk producers and protected protein feed is now being manufactured exclusively by some commercial feed factories, including National Dairy Development Board, Anand, Gujarat (India).

Various Bypass Nutrients

1. **Bypass Proteins**
2. **Bypass Starch**
3. **Bypass Fats**
4. **Bypass/ Chelated Minerals**
5. **Vitamins can also be protected**

Protected nutrient technology:

Protected nutrient technology is one such approach, involving feed management through passive rumen manipulation, by which the dietary nutrients (fat and protein) are protected from hydrolysis, allowing these nutrients to bypass rumen and get digested and then absorbed from the lower tract. The protected nutrients mainly include protected fat and protein and it is also called as bypass nutrients. The other protected nutrients are protected starch, chelated minerals and vitamins. Here, we can discuss only protected fat and protein and its impact of feeding on the performance of cows and buffaloes.

Protected protein:In India, there is a shortage of both energy as well as proteinacious feeds. Protein supplements are more expensive and increase the feed cost. By optimizing the use of protein supplement within the ruminant system, we can either reduce the quantity of protein in the diet or can enhance the production of the animals. The protein can be divided in two parts, for the ruminant animals, in most of the feed, major part is degradable in rumen 'Rumen Degradable Protein' (RDP) and a small but variable amount of dietary protein escape rumen degradation ' Un-degradable Dietary Protein (UDP). UDP which enters the lower tract is absorbed mostly as amino acids following enzymatic digestion. Of the RDP fraction, substantial part is utilized as the N source for rumen microbes, for protein synthesis, while the rest is absorbed as ammonia. Only part of absorbed ammonia is recycled back to rumen as urea via saliva, the rest excreted out through urine. The host animal gets amino acids requirement from two sources i.e. microbial protein and UDP, both flowing to lower tract. Although in the case of low yielder, the microbial protein synthesized in the rumen is sufficient. In some cases microbial protein and UDP is sufficient to meet animal's requirement. In high growing animal and high yielding animals' microbial supply is limited, then the demand of amino acids at the tissue level, so to support the demand, it is necessary to provide proteins in the form of UDP or escape proteins or protected proteins. The protection of protein can be achieved by various methods. Few of them are following:

1. Naturally Protected Proteins: The protein degradability data (in rumen) obtained by several groups of workers on large number of feed stuffs in India and other countries has revealed that only a few feeds are good sources of naturally occurring protected protein (having lower protein degradability), viz., maize gluten meal, cottonseed cake, fish meal, coconut cake and maize grain. Feeds like linseed cake, deoiled rice bran, soybean meal and Leucocaenea leaf meal are of medium protein degradability; while Mustard Cake (MC) and Groundnut Cake (GNC) are highly degradable cakes Negi et al. (1989) found that 50 to 70% of total N in tree forages may be present as protected protein. However, these forages contain 16-53% of total N in the form of acid detergent insoluble nitrogen. This is because of the presence of tannins, particularly the condensed tannins which bind the proteins irreversibly and if fed to animals, are capable of corroding the epithelial lining of the gastrointestinal tract. So, tree forages could be used as a source of protected protein only after devising a method for their tannin detoxification, using either some chemical, biological or biotechnological approach. While the proteins of lower protein degradability do not need any protection, highly degradable cakes like MC, GNC and sunflower seed cake need protection against attack of ruminal proteolytic enzymes, for improving their utilization by ruminants.

2. Heat Treatment: The drying of forage is known to increase the protection of the proteins. During the process of manufacturing oil seed meals, they are subjected to different degree of heating which partly explains differences in the degree of protection. Thorough heating of protein supplement causes denaturation of protein; it provides effective protection against microbial fermentation in the rumen. Heat treatment at 125-

1500 C for 2-4 hours couldprotect proteins very efficiently. High pressure steam treatment with extrusion has shown promising results.

3. Esophageal Groove: This is normal function in young one. It is done/ good for liquid proteins. Groove closer is influenced by various factors such as age, temperature of liquid, posture of animal while drinking, site of delivery into esophagus, and chemical composition of liquid. More over commonly used chemical influencing the closer are Salts of Sodium, Copper, Silver and Zinc.

4. Formaldehyde Treatment: It is most widely used chemical treatment for the protection of protein. Normally we add 3-4 kg of commercial formalin (37-40% HCHO) per 100 kg of CP or 1-1.2 g HCHO/ 100 g CP. The most successful procedure, developed by Ferguson et al. (1967). Generally there is increased fecal nitrogen and decreased urinary nitrogen which indicates effectiveness of protection. The use of formaldehyde to protect dietary protein for ruminants is based on the premise that bound formaldehyde markedly reduces the solubility of the protein at pH 6.0, thereby rendering it highly resistant to microbial attack in the rumen, without significantly reducing its digestibility in the small intestine. Other aldehydes like, acetaldehyde, glutaraldehyde, glyoxal are also effective but they don't possess any advantage over formaldehyde which is comparatively cheaper and easily available.

5. Post Rumen Infusion (Fistula): Surgically fitted fistula after the rumen in the lower tract of intestine is an easy method to avoid rumen microbial degradation of proteins, so proteins/ amino acids are available in the intestine. This method is only used at research level to generate the data and rumen degredation pattern.

6. Encapsulation of Proteins: Encapsulation of Proteins is usually done for good Biological value proteins and for individual amino acids. Methionine and lysine are limiting amino acids in microbial proteins on feed intake, plasma amino acids and milk production. So they can be given the form of capsule with a combination of fats or fatty acids sometimes by addition of carbonate, kaolin, lecithin, glucose etc.

7. Amino Acids Analogs: Structural manipulation of amino acids to create resistance to ruminal degradation is another potential method for rumen bypass of amino acids. In addition to being absorbable from the small intestine, the analog must have biological potency in metabolism by tissue. Analogs such as Methionine hydroxy, N-acetyl-DL-Metionine, DLHomocysteine thiolactone-Hcl, DL-Homocysteine, etc. have given satisfactory results. Reacting amino acids to produce imides, produced materials which survival ruminal conditions, yielded free amino acids at abomasal pH, and increased amino acids concentration in the ruminants.

8. Feed Processing

Normal procedure in the manufacture of feed ingredients can influence the magnitude of protein degradation in the rumen. Certain grain processing can either increase or decrease rumen degradation of Proteins. Increased ruminal degradation may be the result of disruption of the protein matrix, whereas heat applied or generated during grain processing can decrease ruminal degradation of proteins.

9. Lowering Ruminal Protease Activity

By depressing the proteolysis activity of the rumen microbes (not Urease) we can slow down the protein degradation within the rumen. Bacteria are the mainly responsible for proetolytic degradation. So antibiotics can be used to reduce the protein degradation within the rumen.

10. Metal Amino Acid Complex

Metal complexes commonly available such as Zinc Methionine, Zinc Lysine, Copper Lysine, Manganese Metionine, Iron Methionine etc. their usefulness lies in the fact to assume that they must be stable in the rumen environment and abomasum and be delivered to the small intestine intact, secondly, there is some evidence that mineral chelates are considerably better absorbed than inorganic forms.

11. Plant Secondary Compounds

These are mainly secondary metabolism compounds these are generally not utilized in metabolic process these include lignin, tannin, terpenenoids, volatile essential oils, alkaloids etc. these have potential to be used as protein protectant in the rumen. Tannin has got good attention, although it is considered as antinutritional factor but as it is a protein suppresser or decreasing is digestibility so it can be used in the ruminant animal at lower level; for monogastric it is toxic.

12. Decreasing Retention Time in Rumen

Less stay in rumen environment mean less degradation because feed or protein is getting less exposure to enzymatic action. Faster pass of feed in the rumen is the explanation. Factors influencing the rate of passage include food intake, specific gravity, particle size, Concentrate to roughage ratio, rate of rumen degradation etc.

Beneficial Effects of Bypass Proteins

1 Growth Performance

Feeding of bypass protein meals generally increase the growth rate of animals and the increase is often significant. A series of experiments conducted at NDRI, Karnal have shown significant increase in growth rates in calves, buffalo calves, and goat kids on feeding bypass protein. These experiments were on HCHO treated GNC and Mustard cake. The increase in growth rate of these animals was registered to the tune of 30 -40 %. Feeding of Bypass protein to growing stock, not only increases growth rate, but also improve feed conversion efficiency feed required per kg gain and feed cost per kg gain. Infact, it not only results in reduction in the cost of rearing, but due to higher growth rate, it also results in attaining early maturity by male or female animals. This is definitely a bigger boon in terms of improvement in reproductive efficiencies of these animals.

2 Lactating Performance

Most of feeding trails resulted in significant increase in m milk yield and FCM yield. The increase in milk yield varied in the range of 8 – 10 percent. The studies conducted onmedium producing animals, proved that bypass protein feeding can be beneficial to the animals, producing 8-10 liters of milk per day. Significantly increase in milk yield and FCM yield in cross bred cattle in murrah buffaloes and in Goats.

3 Reproductive efficiency

Because of high growth rate caused through protein feeding, the young stock can attain early maturity to start the reproductive life at an earlier age. It has been shown that bypass protein feeding can improve the reproductive efficiency of breeding buffalo bulls and cross bred bucks, both with respect to sexual behavior, including libido score as well as the seminal attributes like ejaculate volume, mass activity and sperm count per ml, similar positive results were obtained in females, where the number of service per conception decreased after feeding of bypass proteins.

Methods of fat protection: The protected fat can be obtained by various methods such as encapsulation technique and calcium salt formation of fatty acids. Calcium salts of fatty acids were produced at NDRI, Karnal by double decomposition method from edible oils and non-edible oils and other products such as acid oil (a byproduct of vegetable oil refining). The calcium salts were prepared by a method described below:

Soybean oil acid oil was heated in a metal container; an aqueous solution of sodium hydroxide was added and again heated to cause saponification, sodium salts so formed were dissolved in excess water. Calcium chloride dissolved in water was then added slowly to the water soluble sodium soaps with stirring causing immediate precipitation of calcium salts. Excess water was removed by squeezing the soaps through cheese cloth. The soap was allowed to air dry and then lumps were broken before being mixed with other concentrate ingredients (Mishra et al., 2004).

Calcium salts are being manufactured commercially from palm **fatty acids** by single stage fusion technique which is more economically viable and environment friendly. These types of protected fats are commercially available in the market.

Productive and reproductive performance of animals fed on protected fat: Adding protected fat to dairy rations can positively affect efficiency of dairy cows through a combination of caloric and non-caloric effects. Caloric effects are attributable to higher energy content and energetic efficiency of lipids as compared to carbohydrates or proteins with the overall benefit being increased milk production and the persistency of lactation. The non-caloric effects include improved reproductive performance and altered fatty acid profile of milk. Feeding Ca soaps of fatty acids to high producing lactating cows resulted in higher milk and milk fat production (Sklan et al., 1991). The higher milk and fat production observed in cows fed Ca salts of fatty acids during early lactation may both be due to higher energy intake, more efficient use of fat and by enhanced tissue mobilization before peak production. McNamara et al. (2003) supplemented Holstein Friesian cows with two protected fat supplements: (1) Megalac Plus (0.4 kg day-1) containing Ca salts of methionine hydroxyl analogue and (2) Megapro gold (1.5 kg day-1) containing Ca salts of palm fatty acids, extracted rapeseed meal and whey permeate and reported higher milk yield in both the groups over that of control.Supplementation of protected fat rich in PUFA to goats not only increased the milk yield but the effects persisted even after the supplement was withdrawn. It was observed that there is direct correlation of the dietary energy intake and body condition to the reproductive performance of animals. Dietary energy intake is low and poor body condition can negatively affect reproductive performance of dairy animals, which results in loss of economic returns to the milk producers.Pregnancy rate was increased by 19% on supplementation of safflower seeds at 0.68 kg day-1 (4.7% fat in the diet) with similar energy and protein content to the late-gestation heifers (Lammoglia et al., 1996).Wehrman et al. (1991) reported that 18% increased in cycling of cows by supplementation with 1.36 kg of whole cottonseed (5.5% fat in diet) 30 day before the breeding season compared to a control diet without added fat. Supplementation of 75% of whole cottonseed to heifers before breeding improved estrus activities and conception rate (Barje et al., 2007).

Reproductive disorders are one of the major factors reducing the milk and affecting the production potential of dairy animals (Ali et al., 1999; Taraphder et al., 2007). Therefore, it will be desirable to incorporate the recent innovations i.e., protected protein and fat in the ration of lactating cows and buffaloes in their early lactation period to avoid the NEB and to enhance the milk productivity with desirable composition which may have far reaching positive influence on their reproductive performance.

CONCLUSION

In developing countries like India, supplementation of protected fat and protein is beneficial to medium and high yielding cows and buffaloes but the cost effectiveness of the same needs to be kept in mind. As about the feeding of protected protein, the results of some farm studies and field studies have indicated the usefulness and cost effectiveness of its feeding to cows and buffaloes yielding around 5-8 L of milk.

In addition, milk fat yield and percentage of unsaturated fatty acids in milk fat was increased, resulting improve nutritive value of milk from a human health point of view.

References on request