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Impact of Bypass Protein Supplementation in Ruminant Animals

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Introduction:

Agriculture including the livestock as an integral component plays an important role in Indian economy. (DAHD & F,MOA, GOI, 2017-18). Livestock is considered a major source of income for the poor masses in developing countries including India, where it contributes, nearly 4.11 percent to total GDP & 25.6% of total Agriculture GDP. (DAHD&F, MOA, GOI, 2017-18; Delgado *et al.*, 2020). The total livestock population is 535.78 million in the country reflecting an increase of 4.6% over livestock census 2012 and total bovine population (Cattle, Buffalo, Mithun and Yak) is 302.79 Million in 2019 which shows an increase of 1.0% over the previous census.

The major constraint in the development of bovine population is poor availability of nutrients through quality feed and fodder (Sarwar *et al.*, 2002). There is a need of 13.5 and 110.3 million tons of crude protein (CP) and total digestible nutrient (TDN), respectively (Anonymous, 2006) to fulfill the requirement of bovine animals therefore improvement in animals demands the efficient use of available feed resources. Area under cultivated fodder in India is about 8.4 million hectare, which is static since last two-three decades & not adequate to meet the fodder demand (Ghosh *et al.*, 2016). The cost on feed and fodder production is further elevated due to climatic aberrations and water scarce conditions. These factors limit the fodder production and creates forage scarcity thus, force the animals to feed on wild shrubs and grasses, and this is recognized as one of the primary causes of lower productivity of milch animals in India (Shankarnarayan, 1984; Patel, 2011). Thus, the constant increase in bovine population in India dilutes any effort made in increasing the feed supply to these animals, through non-conventional feed resources. However, there is also an

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alternative way of increasing the nutrient supply to bovines in these countries, and that is, by modifying the feeds and the feeding conditions, and also by manipulating the digestive tract, or through better feeding management. Such an approach can result in increasing the feed conversion efficiency of feeds within the animal system.

Times when AA balance is critical:

- When attempting to reduce the amount of protein fed, thereby reducing the cost of the diet and increasing the space in the diet for higher energy feeds. For the high producing dairy cow, energy is usually more in deficit than AA. Lowering protein in the diet will also reduce the spilling of nitrogen into the environment and lower the threat of regulation. This becomes an extra bonus and for herds under environmental regulation may be a primary use of AA balance.
- For fresh cows, both to minimize body condition loss as well as increase milk production.

Supplementation of Bypass Protein:

In India, the total annual availability of protein meals is approximately 19-20 MMT, against a requirement of about 30-35 MMT. Out of 20 MMT protein meals produced in the country, approximately 4-5 MMT are exported, which further increases the gap between the requirement and the availability. Protein is usually the first limiting nutrient for cattle fed low-quality forages. In India, farmers feed regionally available protein meals to the dairy animals, along with other ingredients especially in rural villages, remote area and hilly region. A significant part of these protein meals is broken down to ammonia in first stomach of ruminants called rumen having a capacity of 50-60 liters. In the feed fraction of nutrients, which are low or non-degradable in the rumen by the microbes and they are digestible and absorbable at lower tract and become available to animal called as Bypass Nutrient Fraction.

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) or By pass protein. 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. In growing animals and high yielding animal's 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.

When chemically treated protein meals replace untreated one, then due to less degradability of the protein, excessive loss of both nitrogen and energy could be avoided, resulting in an increased energy and nitrogen balance and causing increase in milk yield and different milk constituents. In a typical diet, approximately 40% of the protein eaten must be true protein that escapes degradation, whereas 60% of the protein value can be a mixture of protein and non-protein nitrogen that is degraded and incorporated into the rumen microbes (Tarique *et al.*, 2010). Usually, protein meals are degraded in the rumen to the extent of 65-70 per cent, leading to wastage of nitrogen by its excretion through dung and urine. These protein meals are treated suitably, so as to reduce their degradability in the rumen from 60-70% to 25-30%, in a specially designed airtight plant. Cost of treatment of protein meals is less than a rupee per kg and on feeding one kg treated meal in comparison to untreated; there is increase in milk production by more than a liter. Bypass protein technology is being provided to the dairy cooperatives and private agencies (Gulati *et al.*, 2001).

Important features for bypass protein Supplements:

- High level of crude protein, Optimal essential amino acid Profiles
- About 70-80% of the protein to be in a rumen undegradable form and 75-80% of the rumen undegradable protein to be digestible in the small intestine.

Effects of Bypass Proteins on Animal Performance:

- ❖ Biochemical and nutritional basis by which bypass protein show its effect on animal Performance.
- ❖ Additional supply of amino acids at intestinal and tissue level.
- ❖ Lower ammonia production in the rumen because proteins are fermented to ammonia and low degradation of protein will lower ammonia.
- ❖ Lower urea synthesis in liver as ammonia is being absorbed at lower level.
- ❖ Energy saving process as urea synthesis is at lower level.
- ❖ Excess amino acids go for Gluconeogenesis.

Protection of protein can be achieved by various methods:

1. Naturally Protected Proteins:

- The protein of most of the feed resources is bypass to some extent.
- Percentage of UĐP in Common Feed and Fodder.

Feed	UDP %	Feed	UDP %
Maize (grain)	65	Blood meal	76 – 82
Barley	21(11-27)	Fish meal	71 – 80
Sorghum	52	Meat meal	53 – 76
Bajra	68	Brewers dried	53
Oat grain	14–20	Corn gluten	53
Wheat grain	20–36	Wheat bread	29
Cotton seed meal	41–50	Corn silage	27
Linseed meal	11–45	Rice straw	63
Ground nut meal	30	Wheat straw	45
Rapeseed meal	23	Para grass	52
Soybean meal	28 (15–45)	Cow pea	32 – 45
Sunflower meal	24	Berseem	37 – 52
Subabul	51 – 70	Alfa-Alfa	28

(NRC, 1985; Dutta *et. al*., 1997)

2. Formaldehyde Treatment;

It is most widely used chemical treatment for the protection of protein. Normally formaldehyde added i.e. 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.

Advantages of formaldehyde treatment in the production of bypass protein:

Protein sources differ in their rumen degradability. Some protein meals contain naturally available rumen bypass protein (30 to 50 % of total CP) viz. cottonseed meal, toasted soybean, toasted groundnut meal, maize gluten etc., which can be used in bypass protein feeds. The cost of these ingredients is high, whereas, rapeseed meal, sunflower meal, guar meal etc. are available at cheaper rate but rumen protein by-pass content in these meals is low. Such protein meals having high rumen degradability can be subjected to heat or chemical treatment for increasing the level of rumen by-pass occurring. These by-pass protein meals can enhance the post ruminal supply of critical amino acids (Prasad and Reddy, 1998). Protein meals treated with formaldehyde in sealed chambers, where these undergo formation of complexes resist degradation in the rumen. The process occurs under occupational health and safety procedures (Owens *et al.* 1990). This attributes to HCHO-binding to the proteins by formation of methylene bridges, which makes them resistant to microbial attack.

Treating protein meals with formaldehyde has the following advantages:

- Desired level of protein protection can be achieved. Less expensive than heating.
- Under and over protection of proteins can be eliminated.
- The bio-availability of the essential amino acids can be maximized.
- Helps to control salmonella and reduce mould growth in feedstuffs.

Operational health and safety aspects:

Formaldehyde is widely used in industry and occurs naturally as a constituent of many foods including dairy and meat products, coffee, fruits, smoked. Formaldehyde is converted to formic acid by the action of the formaldehyde dehydrogenase enzyme; formic acid is metabolized to carbon dioxide and water, or incorporated into the one carbon pool or excreted in the urine as a sodium salt (Owens *et al*, 1990). Hence, mammalian systems have the biological pathways to effectively metabolize ingested formaldehyde and there is no evidence to suggest that formaldehyde is a carcinogen when consumed orally (FDA, 1998). The formaldehyde present in treated feedstuffs is metabolized by ruminants and does not significantly change the naturally occurring levels of formaldehyde in meat and milk (Atwal and Mahadevan, 1997). Formaldehyde is approved for use as a feed additive to protect proteins from ruminal degradation, to preserve silages, to maintain animal feeds or feed ingredients free of salmonella, to control fungi and to improve the handling characteristics of oilseeds and meals, and animal fat pre-mixes (FDA, 2004). For treatment of protein meals, level of formaldehyde used is not more than 0.8 per cent. After two days of incubation, formaldehyde level in protein meal is detected below 2 ppm. So, handling of treated protein meals is not a serious problem from animal and consumer health hazard point of view.

3. **Alkali Treatment (NaOH):** 1 %, 2 % and 3% supplementation may increase in rumen bypass ability by 4-5 %.
4. **Alkali Treatment (NH_4OH):** 0.3%, 0.5% and 1.0% supplementation may increase in rumen by pass ability by 7-8 %.
5. **Heat Treatment:** It is the combination of time and heat which decreases the solubility of proteins by creating cross linkages both within or among peptide chains and to carbohydrates. It is done by two methods- Jet sploding method and Extrusion method.In jet sploding method, high temperature treatment of protein is done at 315^{o}C for short time. In extrusion method, heat treatment is done along with steam. But it has disadvantage that, it causes mallard reaction and produces melanoidins.
6. **Oesophageal groove closure:** Oesophageal groove is functional in young animals and nonfunctional in adult ruminants. In adult's animals, certain chemicals activate oesophageal groove like salts of Copper, Silver, Zinc, Sodium etc.
7. **Tannic acid Treatment:** Tannins are polyphenolic compounds. They have greater affinity towards proteins. It has been found that 4% tannin content in diet has increased the protein and amino acid flow to lower GIT and is absorbed in lower GIT and improved the nitrogen retention in animals, thus concluding 4% tannin can be used as protein protectant. Condensed tannin protein complex is insoluble even under acidic conditions.
8. **Use of analogs and derivatives of methionine:** Amino acid derivatives are free amino acids to which a chemical blocking group has been attached to amino group or acyl group. Amino acid analogs are produced by substitution of amino group of amino acid with hydroxyl group .*e.g.* Isopropyl DL-methionine, t-butyl DL- methionine.

Most commonly studied analog is methionine hydroxyl analog of 2-hydroxyl-4-methyliobutanoic acid.

9. **Post ruminal Infusion:** Proteins and amino acids are directly infused into abomasums or duodenum instead of being a part of diet. Among these, formaldehyde treatment is most commonly used and economically feasible.
10. **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.
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.

Optimization of treatment for protein meals:

To avoid over or under protection, protein meals need to be given optimum chemical treatment, so that their digestion in the intestine can be maximized. Maximum protection of protein meals was obtained at 9-10 days of incubation in airtight conditions. Lysine and methionine are reported to be the most limiting amino acids for milk production (Schwab, 1995; Xu *et al.*, 1998).On protection, availability of limiting amino acids increased significantly.

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Table 1: Level of essential amino acids available for absorption in unprotected and protected protein meals:

Essential amino acids	Unprotected Sunflower meal	Protected Sunflower meal	Unprotected Rapeseed meal	Protected Rapeseed meal
Cysteine	0.73	1.84	1.95	3.71
Methionine	0.52	1.31	1.14	2.17
Isoleucine	1.33	3.32	2.90	5.50
Leucine	2.02	5.06	6.10	11.58
Phenylalanine	1.25	3.12	2.76	5.25
Lysine	1.14	2.85	4.12	7.82
Histidine	0.67	1.69	2.01	3.82
Arginine	2.34	5.85	4.26	8.09

(Source: Gulati *et al.*, 2002)

Advantages of Bypass Protein Supplementation:

- Easier to meet the requirement of high milk producing animals, higher availability of amino acids per unit of feed.
- Better utilization of those protein meals having higher rumen protein degradability.
- Improves fat percent in milk and milk yield.
- SNF content of milk can be increased with Bypass protein supplement.
- Better economic returns, for same input cost.
- Positively influenced wool growth and quality in sheep.
- Improves growth in young animals caused through protein supplementation, the young stock can attain early maturity to start the reproductive life at an earlier age. Bypass protein supplementation 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.
- Better resistance against diseases in growing and lactating animals.

Conclusion:

No need of Bypass proteins supplementation for maintenance of animals. This is required for medium and high lactating and growing animals. Good increase in live weight gain in growing animals. It Increases dry matter intake and in milk production by 10-15 % in lactating animals so therefore reduces milk production cost.

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