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Success story of Bypass Protein Technology in India to enhance Milk yield of Cows and Buffaloes

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The unique concept of Bypass Protein

This concept was beautifully elucidated first by the famous Australian Scientist, **Dr. W.T. Scott.** The technology is based on the **concept** that highly degradable feed proteins (some oil cakes) need partial protection against excessive rumen degradation, using either Heat Treatment or mild Formalin Treatment. The later, being very cheap, is widely being used now in preparing Bypass protein feed. However, Dr. Scott proposed this new technology mainly for feeding of high yielding cows, to meet their high demand for amino acid requirement.

Rumen and Ruminants

Ruminants are a class of mammals (Cattle, buffalo, goats and sheep) bestowed with a compound stomach consisting of 4 compartments, Rumen, Reticulum, Omasum an Abomasum (this last one is as good as true stomach in humans). Rumen is the he first and the largest compartment, which is like a large fermentation vat, with a holding capacity of 80-90 liters in an adult cow. Here, the fibrous cellulosic material, which forms bulk of feed for ruminants, is constantly fermented by cellulolytic microorganism, numbering trillion microbes/ml of rumen liquor. These microbes consist mainly of bacteria, followed by protozoa and also some fungi). All these microbes are anaerobic in nature, and operate in the absence of oxygen.

End products of cellulose and starch fermentation in rumen

While the end products of cellulose fermentation are Acetate and butyrate, the end products of starch/sugar fermentation is mainly propionic acid. These are all short chain fatty acids. After absorption from rumen wall, the acetate and butyrate act as precursor for long chain fatty acids synthesis in liver, while propionate acts as a precursor for glucose synthesis in liver. From liver, these nutrients are distributed to meet the nutrient needs of the body.

Feed proteins exhibit differential degradability in rumen

Proteins in rumen are degraded to ammonia via amino acids by rumen microorganisms.

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Subsequently, the rumen microorganisms re-synthesize their own protein from ammonia and carbon dioxide (which is provided through the degradation of starchy feeds in rumen, consumed by the animal. **The microbial protein** (synthesized in rumen) plus the **undegraded dietary protein**, are both **digested in Abomasum**. Subsequently the released amino acids in abomasum are **absorbed from intestines,** to meet the protein and energy needs of the animal.

However, if the proteins fed is highly degradable in rumen, especially from oil cakes like mustard cake, rape seed cake and groundnut cake, then the **excessive ammonia** generated in rumen **changes the rumen pH to Alkaine** side, which then hampers further fibre degradation. This major activity of cellulose digestion in rumen is optimum under neutral pH. Thus, rumen has to be cleared off this excessive ammonia accumulation, in order to maintain its neutral pH. Accordingly, the excessive ammonia produced is **absorbed** from the **rumen wall, transported to liver, where it is converted to urea**, and excreted out through urine.

While I was toying with the idea of studying the relevance of feeding bypass protein to dairy animals under Indian conditions, I happened to hit up on a research paper by Satter and Slyter (1974), which recommended the optimum ammonia concentration in rumen for maximum microbial protein synthesis as 5.0 mg/100 ml of rumen liquor. While in India the levels normally range from 10 to 30 mg/100 ml of rumen liquor. The reason being, poor farmers feed mostly oilcakes from their home-grown crops. However, they do not supply the matching energy source like starchy grains, to provide Carbon dioxide, in order to trap ammonia by microbes for amino acid synthesis.

Thus, in rumen, when large quantities of amino acids are degraded to ammonia on feeding proteins, which are highly degradable in rumen, it is something like **pucca** bricks converted to **mulba**. This waste material (mulba) is of no use to the animal. And to get rid of this mulba from its body, animal has to pay **harjana** (compensation), by using its own calories for the conversion of ammonia to urea in liver, before being excreted out through urine.

So, when commonly available and highly rumen degradable oil cakes are fed to cows and buffaloes, not only lot of their proteins ingested are wasted, but the animal has to spend its own energy to get rid of this waste material (ammonia), which means a double loss to the animal, in terms of both protein as well as energy.

Looking at the above observations, I was inspired to test the relevance of this technology under Indian conditions. However, the foreign experts visiting NDRI, the institute in which I worked all my life, discouraged me from initiating work on this project, putting an argument that Bypass Protein technology is good only for very high yielding animals. Adding further, that this kind of technology has no relevance under Indian conditions, where, cows are mostly low yielding. However, my enthusiasm forced me to swim across the current, and to test the hypothesis, the relevance/ irrelevance of this technology under Indian condition, even if the results failed to show any positive response in terms of increase in milk yield.

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Thus, we started our long and journey involving my team, including my M.Sc. and Ph D. scholars. We conducted experiments on cows, buffaloes and goats, with respect to growth, milk production and some other aspects, including reproduction. The first thing was to find out the optimum level of formaldehyde for sufficiently protecting the protein from ruminal degradation, but without over protecting the protein. We found that 1 g of HCHO per 100 g of crude protein of cake was the optimum level.

Flow rate studies

Next, we designed an experiment to measure the flow rates of amino acids at abomasums, in abomasally fistulated calves, which were fed either highly degradable protein in rumen or less degradable dietary protein (bypass protein). The flow rate of total amino acids was significantly higher at abomasum in the group fed bypass protein, than the group fed the cake, whose protein was highly degradable in rumen. This experiment categorically indicated the better amino acid flow and availability to the animal, on feeding bypass protein.

Growth studies

The growth rates were found to be in the range of 25- 30 % in both cow and buffalo calves, fed bypass protein (formaldehyde treated cake), whereas, it was much higher in the case of goat kids (30-35%).

Positive impact on Reproduction

The higher growth rate in all the three species of ruminants fed bypass protein means early maturity in both, male and female calves, followed by early calving, which means more life time production in cows and more breeding span for bulls.

In addition to that, feeding of bypass protein reduces the circulating levels of ammonia in blood, resulting in reducing the possibility of abortions in pregnant cows.

Milk Yield

The Increase in milk yield was between 12 to 16 % in all the three species of ruminant. The experiment was done on cows with an average of 10 liters /day, and on buffaloes with an average of 7 liters /day. There was no trace of formalin found in the milk of goats fed HCHO treated cake. This demonstrated that when ruminants are fed HCHO treated oil cake, its milk is safe for human consumption.

Reason for more milk synthesis in mammary gland

Increase in growth rate is understandable, which is simply due to increased absorption of amino acids from intestines. But increase in milk yield needs further elucidation.

Normally under village conditions, cows and buffaloes are hardly fed starchy diets. They are fed highly degradable oil cakes, along with fibrous grain byproducts like choker and with very little grains. In other words, it is rather a highly imbalanced diet. Under normal conditions, starch is degraded to propionic acid in rumen and after absorption from rumen wall, serves as a precursor for glucose

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synthesis in liver.

Thus, in such animals fed low starchy diets, the amount of propionic acid produced in rumen is low, and not sufficient enough as required for gluconeogenesis in liver. However, on feeding HCHO protected cakes/ bypass proteins, much higher amounts of amino acids are absorbed from intestines. Thus, in such animals, amino acids replace propionic acid as glucose precursor in liver, resulting in much more glucose being synthesized in liver from gluconeogenic amino acids. All this results in lot more supply of glucose to mammary gland, which leads to more Lactose synthesis there. Lactose, the milk sugar is formed by the combination of Glucose and Galactose in Mamary Gland (MG). Half of the glucose entering MG is first converted to galactose. Subsequently, the 2 sugar moities join together to form Lactose, the milk sugar.

More Lactose synthesis in MG leads to more milk production, because, Lactose regulates the osmotic pressure of milk. Accordingly, the mammary gland has to suck more water from blood to maintain the osmotic pressure of milk, leading to more volume of milk produced.

So, this is the main reason for cows giving more milk after feeding of bypass protein, even in low and medium producing animals, which form the bulk of our cows and buffaloes in India.

Histopathological studies

To ensure that feeding of formalin treated mustard oil cake (Bypass Protein) was safe and had no adverse effect on the health of the animals, the growing goats were later slaughtered and the histopathological examination of the tissues of various organs was performed. **To our utter surprise,** the tissues of the various organs of the goats fed formalin treated oilcake (bypass protein) were absolutely normal. However, there was a massive deterioration in the tissues of the most of the organs of goats fed untreated mustard cake.

Surprisingly, this experiment revealed another positive effect of formalin treatment of mustard oil cake fed to dairy animals. Thus, formalin treatment of mustard cake, not only protects its protein in rumen, **but it also protects the antimetabolite present in this oilcake, viz. Glucosinolate, which, otherwise is converted to a poisonous form, viz. Thiocynate in rumen.** In animals fed untreated mustard cake, thiocynate after absorption from intestines is responsible for the spoilage of most of the organ tissues.

However, overnight soaking of the cakes, as is done under village conditions, the glucosinolates gets oxidized, and the cake is safe for feeding. However, feed manufacturers have to limit the %age of untreated mustard cake in the feed to 6-7% only, in order to avoid toxicity caused by thiocynate poisoning. But after protecting the mustard cake with HCHO, it could be added to the feed even up to 25%, without any adverse effect on the health of the animal.

This was further confirmed when the milk from goats fed untreated mustard oil cake had also the traces of Thiocynate present, whereas the milk from formaldehyde treated group had none.

A similar phenomenon was seen even in groundnut cake also, where we found that the

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growth rate of goat kids was very much restricted after feeding untreated cake, and on the other hand a bumper growth rate in the group fed formalin protected cake. This was obviously due to **the unrestricted fungal growth occurring in untreated cake, thereby resulting in aflatoxin production.**

Other positive effects of feeding bypass protein to ruminants:

1. Lower ammonia levels in rumen improves cellulose/fibre digestion and increases microbial protein synthesis in rumen.
2. Lower ammonia and urea levels in circulating blood are good for the general health of the animals, and pregnant animals in particular.
3. Bypass protein is also an environmentally friendly technology, as there is much reduction in urinary nitrogen loss, which otherwise goes into the atmosphere, causing environmental pollution.

The results of our experiments on bypass protein studies, which were published in Indian and foreign journals, **were being constantly monitored by Dr. Scott, far away in Australia.** He had been already recommending to NDDB for commercializing the technology of Bypass Protein. After seeing our good results and safety of this technology, he was **strongly able to convince and rather recommended Chairman NDDB (**National dairy development Board) for the commercialization of this technology in India. In fact, he suggested to them that before that, NDDB could have a **Collaborative Research Project** to conduct 2 trials on feeding of Bypass protein to cows, one at NDRI Karnal and in the other one under village conditions around Anand, by NDDB.

surprisingly, NDDB trial resulted in greater **increase in milk yield, even up to 20 % under village condition,** as against 12 to 15% increase which we recorded at NDRI farm.

Boyanced by the exciting results of feeding bypass protein under village conditions, NDDB Chairman gave a green signal for the commercialization of the Bypass Protein technology in India, under the collaborative project with CSRIO, Australia, which gave them the technical knowhow for the commercialization.

On the day, the first commercial plant for the manufacture of bypass Protein was to be inaugurated by the Australian high Commissioner in India, at Baroda, a seminar was organized by NDDB at Anand in the forenoon. Two presentations were made during the seminar, one by NDDB representative, Dr. M.R. Garg and the second one by me. It was one of the luckiest moments for me in my life to meet Dr. W.T. Scott from Australia in person, who chaired the above session. He informed me that he was constantly monitoring all the research papers published by our group on bypass protein.

After NDDB, now so many other private players are manufacturing Bypass Protein in the country. **It is quite heartening that today, the Bypass protein technology is the most popular commercial feeding technology in India, benefitting millions of dairy farmers in the country**.

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