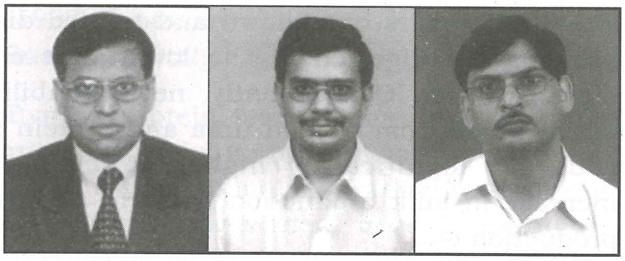
Slow Ammonia Release and Protected Protein (SARPP) Supplement to Economize Milk Production in Dairy Animals



M.R. Garg* P.L. Sherasia* B.M. Bhanderi*[1]

"Protein meal and urea can be treated simultaneously to develop slow ammonia release and protected protein (SARPP) supplement, as a source of slow release ammonia in the rumen and protected protein for digestion in the lower gut. This strategy could be useful to optimize plane of nutrition in ruminants for enhancing supply of amino acids at intestinal level, for various productive functions. Commercial production of SARPP supplement appears to be a very promising process."

INTRODUCTION

As there is shortage of feed and fodder resources in the country, available feed resources would need to be utilized judiciously and with value addition. The current level of milk production by various species of animals suggests that the genetic potential of the animals for milk production is not fully exploited, due to shortage of feed resources. Milk production targets could be achieved if the available feed resources are utilized efficiently and genetic potential of animals for milk production is realized to the maximum possible extent.

Protein forms one of the most significant constituents of the ruminants' ration. It is, therefore, of paramount importance to ensure that this constituent is utilized with high efficiency. All ruminants, including dairy animals, derive their protein requirement from two sources. One is rumen-undegraded feed protein that gets enzymatically digested in the abomasum and small intestine and another source of protein is rumen microbes. If dietary nitrogen intake of ruminant animals is manipulated in such a way, so as to maximize amino acids availability from rumen microbial output and undegraded dietary protein, then the growth and milk production in animals can be maximized with marginal increase in feed cost. Usually, availability of rumen-undegraded dietary protein is maximized through feeding treated protein supplement (Walli *et al*, 2004; Garg, 2006). For efficient growth of rumen micro flora, fermentable nitrogen is made available through urea. However, urea is rapidly hydrolyzed to ammonia and the rumen microbes are not able to utilize this ammonia efficiently for microbial protein synthesis. As a result, a significant part of this nitrogen is lost through urine in the form of urea, for which animal has to spend energy.

Animal Nutrition group at National Dairy Development Board, Anand has developed a Slow Ammonia Release and Protected Protein (SARPP) supplement, in which dietary urea and proteins are simultaneously treated, to ensure efficient utilization of urea by the rumen microbes by

* *Productivity Systems, Animal Nutrition and Feed Technology Laboratory, National Dairy Development Board (NDDB), Anand-388 001 (Gujarat).*

[1] *E-mail: bhanderi@nddb.coop*

slowing down its breakdown and treated dietary proteins are digested in the lower part of the digestive tract. Consequently, net availability of amino acids from treated urea and protein meal could be significantly higher, resulting into increase in milk production, growth, wool, meat production etc.

PRESENT STATUS OF PROTEIN MEALS IN INDIA

Oilseeds and oilseed meals emerged during the 1990s as one of the fastest growing components of global agricultural trade, with developing countries accounting for most of the growth in both supply and demand. Many developing countries — including the rapidly expanding economies of China and India — have become the principal source of growth in demand for feed proteins. India, the world's seventh largest producer of oil crops, is a major producer of soybeans, rapeseed, peanuts, cottonseed and sunflower seed and their meals. Although India is the world's fifth largest exporter of protein meals, the availability of protein meals in the country is limited. Against the current requirement of about 30-35 MMT of protein meals for feeding dairy animals, after the exports only 15-16 MMT protein meals are available annually. Faster income growth is also strengthening demand for animal products and the derived demand for protein meals for feeding. Protein meals available in limited quantity need to be utilized judiciously through bypass protein feed technology by using SARPP supplement that can further enhance nutritional values of protein meals.

RUMEN MICROBES CAN NOT SUPPLY ALL THE PROTEIN NEEDS OF THE RUMINANTS

Animals in India are fed by and large on poor basal diet, deficient in essential nutrients for the growth of rumen microbes. Fermentable nitrogen and carbohydrates are mainly available to rumen microbes from green fodder, grains and other feed ingredients, which are not adequately included in the ration of dairy animals due to availability and cost reasons. As a result of this deficiency, fermentative process in the rumen is low, rumen microbial output is low and microbes are not able to supply desired quantity of amino acids to the host animal. Thus, the quantities of microbes that leave the rumen in digesta do not supply sufficient protein to meet the needs for productivity in ruminants. Evidence is also accumulating to suggest that lysine and methionine are most limiting amino acids for milk protein synthesis in many dairy diets (Xu, *et al*, 1998). Due to these inadequacies in the diet, it has not been possible to fully exploit the genetic potential of dairy animals. Microbial protein formed as a result of rumen fermentation of carbohydrates under anaerobic conditions is one source of protein for ruminants. On many basal diets derived from tropical feed resources, that are low in nitrogen, microbial protein is virtually the only source of protein.

Under these conditions supplementation with a Slow Ammonia Release and Protected Protein (SARPP) supplement to supply additional dietary amino acids increases both the level and efficiency of animal production. Treated urea serve as source of slow release ammonia for the rumen microbes, whereas, protected protein is enzymatically digested in the lower part of the digestive tract, where it supplies more amino acids for milk synthesis. Thus, the technology is applicable to ruminant animals that are fed on deficient diets, irrespective of level of milk production.

METHODS TO IMPROVE NUTRITIVE VALUE OF PROTEIN MEALS AND TO OPTIMIZE THE PLANE OF NUTRITION IN DAIRY ANIMALS

Bypass Protein Feed Supplement

Protein is necessary for growth and to replace the daily break down of body tissues, including muscle, blood, hair and hooves. Protein is usually the first limiting nutrient for cattle fed low-quality forages. Protein is necessary for rumen microbes to digest fibre and other feedstuff components. Protein meals, particularly rumen escape proteins, play a very important role as excellent protein supplement, in livestock feeding. Protein meals are increasingly used in livestock feeding, as the oil finds other commercial applications. When these meals are fed as such to ruminants, about 70 per cent of the protein is broken to ammonia in the rumen and a significant portion is excreted in the form of urea through urine. Higher degradability of untreated protein meal causes an excessive production of NH_3 in rumen, levels higher than the quantities, which rumen microbes could use for microbial protein synthesis. Thus, a significant amount of this NH_3 is absorbed through rumen wall and then partly lost through urine in the form of urea.

However, if these meals are subjected to suitable chemical treatment — termed as "bypass protein technology", then their efficiency of utilization can be significantly improved. 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. Rumen bypass protein supplements produced by the chemical treatment of protein meals are an important source of rumen undegradable protein (UDP) for ruminants. Protein meals treated with formaldehyde to produce bypass protein should have the following characteristics: proportion of UDP 70-80 per cent, bio-available lysine 80-85 per cent, unchanged levels of acid detergent insoluble nitrogen (ADIN) 2.4-3.0 per cent and neutral detergent insoluble nitrogen (NDIN) 4.0-5.0 per cent. These bypass protein supplements could be included in the diets of lactating cows and buffaloes for improving milk yield and composition.

Cost of treatment of protein meals is less than one rupee a kg and on feeding one kg bypass protein supplement, there is increase in milk production by more than a litre (Garg *et al*, 2005). Regionally available protein meals can be treated and fed to animals, either as top feeds or by incorporating them in cattle feed @ 25 per cent. On an average on feeding one kg bypass protein supplement, daily milk yield, fat and protein per cent increased by 0.8-1.2 litre, 0.2-0.5 per cent and 0.2-0.3 per cent, respectively (Garg, *et al*, 2004). Significant effect of feeding treated protein meals on growth and milk production have been demonstrated by other workers as well (Sampath, *et al*, 1997; Santos, *et al*, 1998; Kanjanapruthipong and Buatong, 2002).

Bypass protein feeding has been shown to be quite useful in increasing milk production, especially when animals are energy deficient. The significant improvement in milk production performance on feeding bypass protein feed could be due to the increased supply of amino acids at the tissue level. There are reports by several workers that formaldehyde treatment causes an increased supply of amino acids at the lower tract (Antoniewicz *et al*, 1992; Chalupa and Sniffen, 1996). The improved supply of amino acids in the presence of sufficient metabolizable energy, can improves the protein-energy balance and creates a better balance of precursors for milk synthesis, resulting in increase in milk production.

SARPP Supplement

Of the total protein supplied to animals through diet, a part of it should be fermentable in the rumen to meet nitrogen requirements of microflora in the rumen. Inadequate fermentable nitrogen in the diet will affect microbial growth and reduce fibre digestion in the rumen. Optimum protein nutrition for dairy animals involves formulating rations based on needs of the rumen microbes and the host animal. Protein requirements of rumen microbes can be met by using rumen degradable protein (RDP) sources, while the animal's requirements are supplied by RDP and rumen undegradable protein (UDP). The UDP source (s) must provide amino acids in the correct amounts and proportions to complete microbial protein (created by rumen microbes). Balancing rations based on specific protein and amino acid requirements helps to reduce metabolic inefficiencies and nitrogen excretion associated with overfeeding protein.

Protein is one of the most expensive nutrients to supplement in the diet. Protein from non-protein nitrogen (NPN) is relatively inexpensive, but the most common source of NPN, urea, is released too rapidly in the rumen, to be well-utilized in high roughage diets. This rapid release can cause ammonia toxicity in some instances. Feeding high levels of urea with high forage diets is not as cost-effective because much of the urea is not utilized due to the rapid ammonia release rate of urea. This rapid release of ammonia from urea can exceed the rumen microbe's ability to use the ammonia and results in more ammonia being converted back into urea by the liver and excreted. If urea is fed as such to ruminants, then it may not be efficiently utilized due to its rapid hydrolysis in the rumen (Gustafsson and Palmquist, 1993).

However, if urea is also treated optimally with formaldehyde then it could serve as source of slow release ammonia, for the efficient growth of rumen micro flora. This ensures better fermentation in the rumen and animals get nutrients from the enhanced microbial growth as well as from the undegradable proteins. Thus, improved supply of microbial protein can enhance the availability of amino acids in the small intestine, which can further improve growth and milk production. For the production of SARPP supplement, protein meal and urea can be treated simultaneously, as a source of slow release ammonia in the rumen and protected protein for digestion in the lower gut. This strategy could be useful to optimize plane of nutrition in ruminants for enhancing supply of amino acids at intestinal level, for various productive functions.

Blood Urea-N — An Indicator of Efficient Utilization of Urea

Rumen ammonia can be utilized by rumen microbes depending upon its release rate and availability of precursors for synthesis of microbial protein, or can be absorbed into the blood stream. On feeding SARPP supplement, level of blood urea nitrogen (mg/dl) is significantly low. Low blood urea-N levels indicate that the urea from SARPP supplement can be utilized more efficiently for microbial protein synthesis in the rumen. The synthesis of urea itself is an energy consuming process, which costs 4 moles of ATP per mole of urea synthesized. Thus, loss of excess nitrogen in the form of urea not only causes a decreased efficiency of nitrogen utilization but also causes loss of energy to animals, already fed on deficient diet. However, when SARPP supplement can be fed to lactating animals, this excessive loss of both nitrogen and energy could be avoided. It may result in an increase energy and nitrogen balance causing increase in milk production and yield of different milk constituents. In dairy cattle, blood urea reflects not only the catabolism of protein by the ruminant tissues, but also breakdown of protein and non-protein nitrogen within the rumen by microorganisms (Rajcevic *et al*, 1993).

Allantoin — An Index of Microbial Protein Supply

When the microbes enter the abomasum and the small intestine, they are degraded enzymatically to nucleotides and purine bases. These are then absorbed into the body of the animal. Although these purine compounds may be incorporated into tissues, the amount absorbed greatly exceeds tissue requirements and the majority is excreted via the kidney. The amount of purine derivatives (allantoin, uric acid, xanthine and hypoxanthine) in the urine therefore tend to closely reflect, and can therefore be used to predict the flow of microbial purines into the intestines, thus quantifying the intestinal flow of microbial protein to the animal (Susmel *et al*, 1994). Purine derivatives particularly allantoin in urine can be considered as a tool for estimating microbial protein supply to the ruminants.

On feeding SARPP supplement, level of allantoin (mmol per litre) in urine of dairy animals is significantly higher. Level of allantoin in urine is an indicator of microbial protein synthesis in the rumen (Rys *et al*, 1975). With the knowledge of the purine:protein ratio in microbial biomass, microbial protein absorption can be calculated from the amount of purine absorbed which in turn is estimated from urinary excretion of allantoin (Chen *et al*, 1990). It is expected that the slow release ammonia from the SARPP supplement is utilized more efficiently for the synthesis of microbial protein. Vercoe (1976) reported that allantoin excretion is positively correlated with the digestible dry matter intake in buffaloes, but compared with the cattle, the excretion is much too low. Subsequent studies of Liang *et al* (2003), Chen *et al* (1996) and Thanh *et al* (2003) confirmed the same observation. Chen *et al* (1996) suggested that the possible difference is due to the partitioning of plasma purine derivatives between renal excretion and non-renal disposal and that a low glomerular filtration rate in buffaloes. Thus, on feeding SARPP supplement, level of allantoin in the urine of animals is more, indicating higher microbial protein synthesis in the rumen.

Milk Quantity and Quality

On feeding SARPP supplement, due to enhanced supply of amino acids through microbial protein and undegraded feed protein to the small intestine, there is further increase in daily milk yield, fat and protein per cent, as compared to that of feeding protected protein only (Garg, *et al*, 2006a). The significant improvement in milk production performance could be due to the increased supply of amino acids at the tissue level. Methionine and lysine are the two most important limiting amino acids for the productive performance of animals. Chalupa and Sniffen (1996) reported that the increased supply of essential amino acids in protected form causes an increase in milk production. Methionine in particular, plays a significant role as a methyl donor during milk fat synthesis, and is also the precursor for phospholipid component i.e. choline synthesis. The improved supply of amino acids in the presence of sufficient metabolizable energy, can improves the protein-energy balance and creates a better balance of precursors for milk synthesis, resulting in increase in milk production.

Advantages of SARPP Feeding

- Efficient utilization of urea by the rumen microbes.
- Higher net availability of amino acids from microbes and protein meal.
- Judicious utilization of protein meals, available in limited quantity.
- Improves growth and milk production.
- Improves fat and protein per cent in milk.
- Better economic returns, with very little input cost.

OPERATIONAL HEALTH AND SAFETY ASPECTS

Mammalian systems have the biological pathways to effectively metabolize ingested formaldehyde. Formaldehyde dehydrogenase enzyme converts formaldehyde to formic acid, which metabolizes to CO_2 and H_2O. There is no evidence to suggest that formaldehyde is a carcinogen when ingested within the safe limits however, its vapour can cause sensory irritation of the eyes, nose and throat and is potential carcinogen (WHO, 2004; FDA, 1998). FDA (2004) approved use of formaldehyde 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. Maximum limit of formaldehyde in all these preparations should not exceed 1.0 per cent. For production of SARPP supplement, level of formaldehyde used is not more than 0.3 per cent of the supplement and during production of SARPP supplement, level of formaldehyde in background air does not exceed 0.2 ppm. Therefore, its production and use does not pose any risk to human beings and animals.

CONCLUSION

To optimize the plane of nutrition in dairy animals by feeding SARPP supplement, protein meal and urea can be treated simultaneously, where urea serve as a source of slow release ammonia in the rumen and protected protein for enzymatic digestion in the lower gut. It appears to be a promising feed supplement for increasing milk yield and composition in dairy animal, with very little input cost and could be more useful for the countries having deficiency of quality feed resources. Commercial production of SARPP supplement appears to be a very promising process. Handling of treated protein meals and urea is not a serious problem, from animal and consumer health hazard point of view.

REFERENCES

*Antoniewicz, A. M., Van Vuuren, A. M., Vender Keeled, C. J. and Kosmala, I. 1992. Intestinal digestibility of rumen undegraded protein of formaldehyde treated feedstuffs measured by nylone bag and in vitro technique. Animal Feed Science and Technology **39**:111-124.*

*Chalupa, W and Sniffen, C. J. 1996. Protein and amino acid nutrition in lactating dairy cattle - Today and tomorrow. Animal Feed Science and Technology, **58**: 65-75.*

*Chen, X. B., Hovell, F. D. DeB and Orskov, E. R. 1990. Excretion of purine derivatives by ruminants: Recycling of allantoin into the rumen via saliva and its fate in the gut. Brit. J. Nutr., **63**:197-205.*

*Chen, X. B., Samaraweera, L., Kyle, D. J., Orskov, E. R. Abeygunawardene, H. 1996. Urinary excretion of purine derivatives and tissue xanthine oxidase (EC 1.2.3.2) activity in buffaloes with special reference to differences between buffaloes and Bos taurus cattle. Br. J. Nutr. **75**: 397-407.*

FDA, 1998. 'Indirect Food Additives: Adjuvants, roduction Aids and Sanitizers.' Feed and Drug Administration, Department of Health and Human Services, Washington, DC. 21CFR Part 178 (Docket No. 97F-0440).

FDA, 2004. 'Food Additives Permitted in Feed and Drinking Water of Animals: Formaldehyde.' Food and Drug Administration, Department of Health and Human Services, Washington, DC. 21CFR Part 573 (Docket No. 1998F-0552).

*Garg, M. R., Sherasia, P. L., Bhanderi, B. M., Gulati, S. K. and Scott, T. W. 2004. Effect of feeding protected protein on milk production and composition of lactating cows. Indian Vet. Journal, **81(1)**: 48-50.*

*Garg, M. R., Sherasia, P. L., Bhanderi, B. M., Gulati, S. K., Scott, T. W. and George, P. S. 2005. Economic evaluation of feeding bypass protein feed on milch animals in Vadodara district of Gujarat. Indian J. Dairy Sci., **58 (6)**: 420-425.*

*Garg, M. R. 2006. Nutritional approaches relevant to dairy animals in India. Indian Dairyman, **58 (11)**: 37-43.*

Garg, M. R., Sherasia, P. L. and Bhanderi, B. M. 2006a. Development of slow ammonia release and protected protein supplement and effect of it's feeding in lactating cows and buffaloes. Indian J. Dairy Sci. (Under publication).

*Gustafsson, A.H. and Palmquist, D.L. 1993. Diurnal variation of rumen ammonia, serum urea and milk urea in dairy cows at high and low yields. Journal of Dairy Sci., **76**: 475-484.*

*Kanjanapruthipong, J. and Buatong, N. 2002. Effects of rumen undegradable protein and minerals proteionate on early lactation performance and ovarian functions of dairy cows in the tropics. Asian-Aust. J. Anim. Sci. **15(6)**: 806-811.*

Liang, J. B., Pimpa, O., Jelan, Z. A., Abdullah, N. 2003. The Book: "An overview on the use of urinary derivatives excretion as a method for estimation of rumen microbial protein production in swamp and zebu cattle".

*Rajcevic, M., Jazbec, I. And Ponikvas, M. 1993. Urea in milk and blood as indicator of nutritive matter supply in high-yielding dairy cows. Zbornik Biotehniske Fakultete Univerze Edvasda Kardelja V Ljubljani, Kmetijstvo, 62: 179-184 (Cited: Dairy Science Abstracts, **57**: 498.*

Rys, R., Antoniewicz, A. and Maciejewicz, J. 1975. Allantoin in urine as an index of microbial protein in the rumen. In Tracer Studies on Non-protein Nitrogen for Ruminants. International Atomic Energy Agency, Vienna. pp 95-98.

*Sampath, K. T., Prasad, C. S., Ramachandra, K. S., Sundareshan, K. and Subbarao, A. 1997. Effect of feeding undegradable dietary protein on milk production of crossbred cows. Indian J. Anim. Sci. **67(8)**: 706-708.*

*Santos, F. A. P., Santos, J. E. P., Theurer, C. B. and Hubes, J. T. 1998. Effects of rumen undegradable protein and dairy cow performance; A 12 Year Literature Review. J. Dairy Sci., **81**: 3182-3213.*

*Susmel, P., Stefanson, B., Plazzotta, E., Spanghero, M. and Mills, C.R. 1994. The effect of energy and protein intake on the excretion of purine derivatives. J. Agric. Sci. Camb. **123**: 257-265.*

Thanh, V. T. K., Ba, N. K., Orskov, E. R. 2003. The Book: "Estimation of Rumen Microbial Protein Production from Urinary Purine Derivatives in Buffalo".

Vercoe, J. E. 1976. Urinary allantoin excretion and digestible dry matter intake in cattle and buffalo. J. Agric. Sci. Camb. **86**: 613-615.

Walli, T. K., Sirohi, S. K. and Garg, M. R. 2004. Milk yield and milk composition of crossbred cows as affected by feeding formaldehyde treated mustard cake. Proceedings of V Biennial Conference of Animal Nutrition Association held at NIANP, Bangalore, **November 24-26, 2004**: 25-26.

WHO, 2004. International Agency for Research on Cancer. Press Release No. 153. (World Health Organization: Cedex, France).

Xu, S., Harrison, J. M., Chalupa, W., Sniffen, C., Julien, W., Sato, H., Fuvieda, T., Watanabe, K., Veda, T. and Suzuki, H. 1998. The effect of ruminal bypass lysine and methionine on milk yield and composition of lactating cows. J. Dairy Sci. **81**: 1062-1077.