

Bypassing the Rumen with Lipids and Protein

G. K. Macleod, Ph.D.
Department of Animal Science
University of Guelph
Guelph, Ontario, Canada

One of the most significant developments in ruminant nutrition in recent years has been that of learning to manipulate diets for more effective digestion and production. One of these techniques has been to bypass the rumen when digestion of protein or lipid is not desirable at this site. By bypass we mean that proteins and/or lipids pass through the reticulo-rumen without being affected by rumen microbes and without altering normal bio-chemical processes in the rumen.

Why bypass the rumen?

In general it is to improve animal performance and efficiency. More specifically in the case of lipids it may mean increasing the energy intake by the cow, changing fatty acid composition of milk and depot fat and increasing milk yield and fat test and yield.

In the case of protein the chief value should be an improved supply and balance of essential amino acids to ruminants which should result in improved growth rates, milk yield and feed efficiency. Utilization of dietary nitrogen (N) should be more efficient and the potential exists for more effective use of non-protein-nitrogen (NPN).

How does it work?

Let us review normal digestion processes involving lipid and protein in the reticulo-rumen and look at research and development in the control of digestion.

Lipids: Normal digestion

Ingested triglycerides are hydrolyzed in the rumen and polyunsaturated fatty acids are hydrogenated, i.e. made more saturated. It is because of this process that fat on milk and depot fats of ruminants are fairly highly saturated. When fat intake exceeds approximately 5 percent of the diet the fat depresses digestibility of the diet and fibre in particular by reducing activity of cellulolytic organisms in the rumen. High levels of fat intake and in particular unsaturated fats reduce acetic acid production and increase propionic acid. This shift in volatile fatty acids results in depressed milk fat tests of lactating cows. Mineral utilization may also be reduced. For these reasons addition of fat has traditionally been limited to 5 percent or less of the diet.

Protected lipids and rumen bypass

Australian scientists have developed a process of encapsulating fat with formaldehyde-treated protein which

enables both the fat and the protein to bypass the rumen. The lipid, for instance, is said to be protected because it neither affects rumen metabolism or is itself affected by rumen microorganisms. In this way higher levels of fat can be fed to ruminants without the effects listed above.

One intent of the Australians was to bypass the rumen with polyunsaturated fatty acids and in this way produce milk and carcass depot fats rich in polyunsaturated fatty acids (Scott, et al. 1971). While the process does work it has not been widely accepted commercially.

Research in North America, Britain and other countries has emphasized the use of protected fat as a significant alternate source of energy and in many studies used animal tallow a highly saturated fat source. Total energy intake by growing cattle and by lactating cows has not been consistently increased by the feeding of protected tallows. The greater concentration of dietary energy in fat-rich diets is frequently offset by lower total dry matter intake (Garrett et al. 1976, Macleod et al. 1977 for example). Favourable results with growing cattle have been reported however. For instance in Texas research where 8 percent tallow was added as protected lipid, growth rate, feed efficiency and marbling score improved (McCarter and Smith 1978). Feed efficiency was improved on Holstein male calves when protected tallow was included in calf starters (Fisher 1980). However no commercial use is being made of protected lipid in growing and fattening cattle today. This is for reasons of cost and limited market opportunity in Canada, whereas in the United States it is because F.D.A. has not approved formaldehyde protected lipid or proteins for feeding to any ruminants. The only commercial application of protected lipid on a commercial scale is for dairy feeds in Canada. This holds despite the considerable research and development work sponsored by Alta Lipids, U.S.A. and Alta Lipids, Canada.

Our research and that at other stations has demonstrated the value of protected lipid in raising milk fat tests, particularly when they have been depressed by heavy feeding. A slight drop in protein content of milk is sometimes observed. The extent of the changes in milk and protein relates to the level of fat fed. Some feed intake depression has been observed. For this reason and others, levels recommended by Alta Lipids Canada are lower than sometimes fed to research cattle. Five to 10 percent in the grain mix of dairy cows in the first half of lactation is suggested compared to 15-30 percent researched earlier. In

both research and field experience increases in milk yield are sometimes observed. Claims for protected lipid also include better energy balance and improved reproducer performance. While research was conducted on a variety of feedstuffs, soybean meal treated with formaldehyde and encapsulating tallow have been most extensively tested and used. Alta Lipids Canada has recently modified the product (brand name Protec) to utilize a combination of rapeseed and rapeseed meal (Canola seed and Canola meal). Protec may be allocated by topdressing on rations or it may be mixed with concentrates or in a total mixed ration. Protec is currently being produced in Alberta and is shipped to Ontario and Quebec. Cost is high but increases in milk yield and/or fat test have been sufficient to encourage the use of Protec on a significant number of farms. Alta Lipids Canada is working with a major manufacturer of dairy feeds on testing a product which places greater emphasis on protein bypass and which does not involve formaldehyde. This appears promising for both USA and Canada.

Protein: normal digestion

A schematic summary of the fate of dietary nitrogen (crude protein) is shown in Figure 1. Crude protein consists of true protein and non-protein-nitrogen (NPN). The more degradable protein experiences the same fate as NPN. Rumen degradable protein is required for normal microbial activity and digestion in the rumen, and most systems are optimized when microbial activity is at its maximum. At maximum microbial activity sufficient microbial protein is produced and digested in the small intestines to meet the amino acid needs of dry and low producing cows and older growing cattle. But for the high yielding dairy cow and rapidly growing young ruminant additional amino acids from bypass protein are required. Whether the diet supplies sufficient bypass protein or not depends on the relative degradabilities of dietary proteins as well as other factors such as level of protein in the diet, level of feed intake and rate of passage through the rumen. Estimated degradability

of several feeds are shown in Table 1. Resistance to degradation is increased as feeds are dried through heating. The extent of change depends on the severity of exposure to heat (time and temperature).

Table 1. Estimated Rumen Degradability of Proteins

Degradability	Forages	Concentrates
1.0		Urea
0.8 ± 0.1	Green chop Unwilted silages	Casein Linseed meal Peanut meal Barley
0.6 ± 0.1	Corn silage Haylage Immature hays	Soybean meal Cottonseed meal Oats
0.4 ± 0.1	Mature hays	Dried brewers grains Corn gluten meal Corn Milo
Below 0.3	Corn cobs Straws	Fish meal Corn gluten feed

Chalupa, 1980.

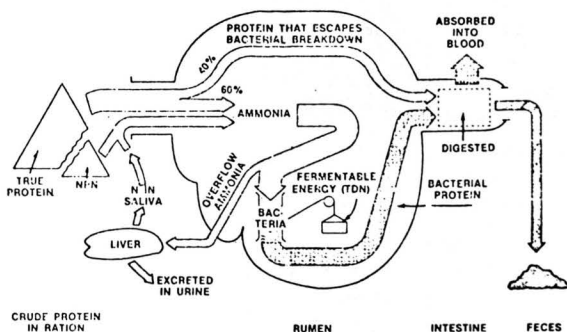
Protected protein and rumen bypass

The objective in protecting protein is to alter degradability so that enough protein of desired quality bypasses the rumen to meet the requirements of the ruminant for essential amino acids. Enough degradable protein must be supplied and the less degradable bypass protein must be digestible in the intestines (not overprotected) and of the required amino acid balance. The value of such a balance was vividly demonstrated when methionine or methionine-rich protein was infused into the abomasums of fistulated sheep. Wool, which is high in S-amino acids, grew dramatically faster.

For calves and high-yielding cows two approaches are practical. Greater bypass may be achieved either through selection of feeds of lower degradability or by treating feeds with heat or chemicals to reduce degradability. Majdoub et al (1978) in Texas demonstrated that milk yield could be improved through selecting ingredients for dairy rations that are of relatively low degradability. This concept has been utilized in the "Protein Plus" program of Agway and other cooperatives tested at the Cooperative Research Farm near Syracuse, N.Y. and widely used in dairy herds particularly in the northeastern states. Due to the restrictions on choice of ingredients such rations cost more and are recommended for the better producers under good management conditions.

Formaldehyde treated protein-rich feeds have been tested

Figure 1. Schematic summary of nitrogen utilization by the ruminant.



in numerous experiments with somewhat mixed results. However, positive benefit in terms of extra milk yield by dairy cows or faster live weight gains by calves has resulted when the optimum level of formaldehyde was used and fed to animals at no higher than recommended level of protein in the diet of cattle capable of responding. This is exemplified in the studies of Kaufman and Luppig (1979) who significantly increased milk yields of cows fed formaldehyde treated soybean meal. This work and that of others has led to commercial use of formaldehyde treated protein in rations of dairy cattle in West Germany, France and Britain. It is likely that chemically treated proteins such as sodium hydroxide treated rapeseed or soybean meal will find commercial application in North America in the near future.

For the future we must know more about amino acid requirements of ruminants and how to meet them. Balancing rations on the basis of nitrogen content (crude protein) is very inadequate. Systems of describing ruminant needs for amino acids and the value of feeds have been developed by various groups and individuals. For example in the US, Burroughs et al (1975), and Satter and Roffler (1975) and in Britain, Roy et al (1977), in France, Verite et al (1979) and in East Germany, Kaufmann (1977) have developed such systems. Much research is needed to confirm or refute their hypotheses and to develop methods for quickly and economically assessing the metabolizable protein value of feeds.

The potential benefits of such research are that by better meeting the needs of rumen microbes and of the host animal, we will be able to realize higher milk yields and growth rates, improved feed efficiency and more economical feeding of protein, more effective use of NPN, better feed intake and energy balance and improved reproductive performance by cows and better health. And in this computer age we should

realize more flexibility in meeting energy and amino acid needs of ruminants.

References

- Burroughs, W., D. K. Nelson, D. R. Mertins 1975. Protein physiology and its application in the lactating cow: the metabolizable protein feeding standards. *J. Anim. Sci.* 41: 933-944. - Chalupa, W. 1980. Methods for estimating protein requirements and feed protein values for ruminants. *Feedstuffs* June 3. pp. 18-21. - Fisher, L. J. 1980. A comparison of rapeseed meal and soybean meal as a source of protein and protected lipid as a source of supplemental energy for calf starter diets. *Can. J. Anim. Sci.* 60: 359-366. - Garrett, W. N., Y. T. Yang, W. K. Dunkley and L. M. Smith. 1976. Energy utilization, feedlot performance and fatty acid composition of steers fed protein encapsulated tallow or vegetable oils. *J. Anim. Sci.* 42: 1522-1533. - Kaufmann, W. 1977. Calculation of the protein requirements of dairy cows according to measurements of N metabolism. In: *Protein Metabolism and Nutrition*. E.A.A.P. Publ. No. 22. Centre for Agricultural Publishing Wageningen, pp. 130-132. - Kaufmann, W., and W. Luppig 1979. The influence of protected protein and protected methionine on milk yield and milk composition of dairy cows. 30th Ann. Meeting of E.A.A.P. Harrogate, England. - Macleod, G. K., Y. Yu and L. R. Schaeffer. 1977. Feeding value of protected animal tallow for high yielding dairy cows. *J. Dairy Sci.* 60: 726-738. - Majdoub, A., G. T. Lane and T. E. Aitchison. 1978. Milk production response to nitrogen solubility in dairy rations. *J. Dairy Sci.* 61: 59-65. - McCartor, M. M. and G. C. Smith 1978. Effect of protected lipids on feedlot performance and carcass characteristic of short-fed steers. *J. Anim. Sci.* 47: 270-275. - Roy, J. H. B., C. C. Balch, E. R. Orskov and R. H. Smith 1977. Calculation of the N-requirements for ruminants from nitrogen metabolism studies. In: *Protein Metabolism and Nutrition*. E.A.A.P. Publ. No. 22. Centre for Agricultural Publishing and Documentation, Wageningen. pp. 126-129. - Satter, L. D., R. E. Roffler 1975. Nitrogen requirements and utilization in dairy cattle. *J. Dairy Sci.* 58: 1219-1237. - Scott, T. W. L. J. Cook and S. C. Mills. 1971. Protection of dietary poly-unsaturated fatty acids against microbial hydrogenation in ruminants. *J. Amer. Oil. Chem. Soc.* 48: 358. - Verite, R. M. Journet and R. Jarrige. 1979. A new system for the protein feeding of ruminants: The PDI system. *Livestock Prod. Sci.* 6: 349-367.