THE REQUIREMENTS OF LIVESTOCK FEEDS:

Presented to: Soil Fertility Workshop, Saskatchewan Advisory Fertilizer Council

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The discussion of Livestock Feeds today will relate primarily to feeds for ruminant animals. My objective in participating in the program are two fold: Firstly to provide some background and review the nutrients required in feeds for ruminant animals and secondly bring to those of you who are not working directly in animal nutrition a few of the recent developments in ruminant nutrition as I see them.

A brief consideration of the distinguishing features of the ruminant digestive system might be useful in setting the stage for this discussion.

We are all familiar with the anatomy of the ruminant digestive system. The rumen acts as a large fermentation vat and is inhabited by a large population of bacteria and protoza which ferments the bulk of the feed received by the host ruminant before the host has an opportunity to digest the feed in the sense that digestion occurs in non-ruminants.

This fermentation has at least two important implications. Firstly fermentation of carbohydrates results in the production of relatively large amounts of Volatile Fatty Acid's,(VFA) which are by-products of the fermentation from the view point of the microbes, but which are absorbed and utilized by the host animal as a major source of energy. V.F.A. provide perhaps 3/4 of the energy supplied by rations consisting mainly of forage. The well known ability of rumen animals to ferment cellulose and hemi cellulose which are major constituents of forage depends on the fermentation process. When ruminant animals are fed diets containing large amounts of starch (high grain rations) rumen fermentation with the subsequent production of V.F.A. becomes a less important source of energy and more energy is derived by absorption of starches and sugars from the intestines by a process similiar to that which occurs in non-ruminant.

The second important implication of rumen fermentation from a nutritional standpoint lies with the effect of fermentation on protein.

A large proportion of dietary protein is fermented in the rumen to provide the rumen microbes with a source of energy. The end products of the fermentation include fatty acids and ammonia. The rumen microbes then utilize the ammonia produced as a source of nitrogen for the synthesis of microbial protein. Energy required for this synthesis is often supplied by the fermentation of cellulose which is a fairly slow process resulting in a relatively slow release of energy. The host animal later digests the microbes and utilizes the amino acids derived for body synthesis or repairs. This unique system of digesting protein provides the ruminant animal with a relatively consistent "quality" of protein, regardless of the amino acid balance of the protein supplied. For example it is well established that microbes can utilize inorganic sulfur in the formation of the sulfur containing amino acids, methionine and cystine, thereby overcoming the necessity of supplying precisely these amino acids, which are often limiting in non-ruminant diets.

It is of interest to note that the host animal may act as a sort of reservior for storing ammonia for the ultimate use by the microbes. During periods of rapid protein fermentation NH_3 is absorbed from the rumen into the blood supply of the host. If protein is in abundance some of the NH_3 will be converted to urea in the liver and excreted. However if the diet supplies a limited amount of protein much of the NH_3 is returned to the rumen to be utilized by the microbes for protein synthesis and only small quantities are excreted in the urine. Providing other nutrients required by the microbes are present in the diet, virtually no protein, as such, is required in the ration of the ruminant animals. Virtanen in Europe has successfully raised dairy heifers on purified rations which contained over 99% of the nitrogen in the non protein form. On this ration the animals grew, conceived, and produced up to about 5480 Kg of milk per lactation.

The features of rumen fermentation already stressed are; the ability to utilize cellulose and hemicellulose, and the utilization of nitrogen more or less independently of the amino acid composition of the nitrogen source. This phenomena may well assure the future of the ruminant in Animal Agriculture in the years to come since these abilities mean that the ruminant can utilize feeds which will not be required directly to feed the growing human population of the world. Indeed the ruminant may become ever more competitive with non-ruminants even though they require more pounds of feed to produce a pound of meat than do poultry or swine.

With this brief background let us look at the nutrients which are required in the diet of ruminants.

1. <u>Energy</u>

Energy is listed as the first nutrient because it is required in the greatest quantity and is generally the most expensive nutrient to provide even though other nutrients may be considerably more expensive on a per unit basis. Table A illustrates this point.

Energy is also important to the nutritionist because the concentration of energy in a ration determines to a considerable extent, the concentration of other nutrients required in the ration.

For example a ration for wintering beef calves containing 1140 kcal of digestible energy per pound should contain 10% protein, while a ration containing 1260 kcal/pound would require 11.1% protein (on a dry matter basis).

Let's digress for a moment from discussing energy as a nutrient and look at energy concentration in various feeds shown in Table B.

With reference to the forages listed, note that forages which are commonly considered to be of high quality have the highest concentration of energy per pound while those defined as being of low quality have a low energy concentration. Indeed many researchers are now attempting to define "forage quality" in terms of energy concentration. A high concentration of energy in forage is desirable from two standpoints. Firstly, the animal consuming the forage receives more energy per pound of forage consumed and secondly, the amount of forage consumed daily, often referred to as "voluntary intake" will generally be higher, because the forage can be more rapidly digested by the process of rumen fermentation.

The popularity of corn silage in areas suited to its production attests to the importance of energy content in feeds. Corn silage is a high energy feed, both in terms of energy concentration (corn silage on a dry matter basis contains about 1400 Kcal D.E. per pound vs. 1080 Kcal D.E./pound in alfalfa-brome silage on a dry matter basis), and in terms of energy produced per acre.

The energy concentration of ruminant feeds is particularily critical in rations for animals which are required to perform at levels substantially above maintenance, for example high producing dairy cows and finishing beef cattle. Since total feed intake is obviously a limiting factor fairly high energy concentrations are required in rations for these classes of ruminants.

Recognizing the limitations of climate, it would appear that one of the prime requisites for successful ruminant livestock production, particularily from the standpoint of dairy production and feedlot finishing of beef cattle, is the production of feeds which:

(1). provide a relatively high concentration of energy per pound, and

(2). will provide for a high production of energy per acre devoted to the crop.

Indeed I believe that such a feed is required to sustain the recently expanded feedlot industry in this province past the end of the present wheat glut.

It should be pointed out that some forms of production, notably cow-calf production do not require high energy concentrations in the rations. Low or medium quality forages are used satisfactorily. By-products of cereal and oil seed production may be used in increasing amounts for this type of production in the future.

One final point should be made about energy. The energy content of feeds are difficult to determine accurately by chemical means because of the wide variety of feed constituents which contribute energy. Also, the systems used in the past to evaluate energy requirements of animals have had rather severe limitations. Research is currently going on to develop more reliable energy evaluation systems. It is likely that an improved energy system for ruminants will replace the T.D.N. system. The adoption of a new energy system by researchers and extension personnel will require considerable extension activity to aquaint livestock producers and others with such a system.

<u>Protein</u>

The protein content of feeds, however important, has often been over-rated. Feeds are often classed, especially by livestock producers, according to their protein content, with the impression that protein is the most important indicator of feed quality. Adequate protein in the ration is no more important than adequate energy, minerals or vitamins. It should be noted, however that protein is considerably more expensive per unit, than energy. (see table C). This means that when supplemental protein is required in a ration the cost of the supplement will be a very significant part of the total ration cost.

Livestock producers should recognize the protein requirements of the class of animal they are feeding and attempt to produce crops which meet their needs. More protein is required, for example, in the ration of calves than in the ration of mature beef cows.

Note from Table C that the cost of supplying protein from urea is far cheaper than from any of the plant sources listed. Considerable non-protein nitrogen is used in ruminant rations at present and the amount used can be expected to grow in the future.

Research is going on at the present time to improve the utilization of non-protein nitrogen, and may well increase this usage more rapidly than expected. At least two methods of improving utilization are being investigated. One method involves modifying urea or finding a suitable substitute which will release ammonia more slowly so that the rumen microbes can use it more efficiently. Another approach involves the addition of some compound to the diet which will inhibit the bacterial enzyme, urease, which is responsible for the rapid conversion of urea to ammonia.

Minerals

Essential minerals include calcium, phosphorus, sodium, chlorine, iodine, cobalt, copper, zinc, iron, selenium, fluorine, potassium, magnesium, sulfur, manganese and molybdenum.

In rations for ruminants, calcium, phosphorus, sodium, chlorine, iodine and cobalt are of general concern. Special area problems occur where soil and plants may be too high or too low in one or more of the other minerals. Selenium is one mineral which can be placed in the catagory.

Forages, especially legumes are generally high in calcium while grains are very low in calcium. Phosphorus, on the other hand may often be in short supply in forages. Note from table A that the cost of providing supplemental phosphorus is considerably higher than the cost of providing calcium.

In an experiment carried out in Alberta in the 1950's on grey wooded soil, the average phosphorus content of pasture over a three year period was raised from 0.18% of the dry matter to 0.31% by the annual application of 300 pounds per acre of 11-48-0 fertilizer in the spring. Phosphorus content of the forage production from the unfertilized pasture was 3.54 pounds per acre while 11.38 pounds per acre of phosphorus were contained in the forage produced from the fertilized pasture. Assuming that 50% of the plant phosphorus was available to the grazing animals, this phosphorus would be worth about $1.84 when valued in terms of the cost of providing supplemental phosphorus.

The same pasture showed an average increase in production of energy of 560 pounds of T.D.N. per year (from 900 to 1460 pounds per acre) due to the fertilizer treatment.

Valuing T.D.N. at 2¢ per pound the value of the energy produced due to the fertilizer treatment would be $11.20. Note that the increased energy produced is worth about 6 times the phosphorus resulting from the fertilizer treatment. Yield in terms of pounds of dry matter per acre was 1970 pounds per acre on the unfertilized pasture and 3672 pounds on the fertilized field.

Vitamins

All of the known vitamins are required by ruminants but many are not dietary essentials as they are produced in the body. In most instances all of the ruminants requirements for B vitamins are synthesized in the rumen.

From a practical standpoint the fat soluable vitamins A, D, and E should be considered. These vitamins are available in synthetic, stabalized form and are fairly widely supplemented in ruminant rations.

Summary

Energy is of major importance in livestock feed. Efforts towards the improvement of feed crops, including fertilizer practices, should be directed at efficient production of energy. The cost to our livestock producers of producing or buying energy is probably the most significant factor in determining their ability to compete with livestock producers of other regions of North America and the world. The concentration of energy in the ration must be balanced for the type of production desired. Feed crops should contain a level of energy concentration suitable for the production desired.

In the case of some nutrients, notably protein and phosphorus, where these nutrients are present at levels below those desired in the final ration, consideration should be given to the economical feasability of increasing these nutrients in the crop used. The cost must be balanced against the cost of providing the nutrient in question directly to the animal from the most economical supplement available.

TABLE A COST OF SUPPLYING NUTRIENTS IN VARIOUS RATIONS FROM SOURCES COMMONLY UTILIZED (cents/day).

Ration for:	Energy[1]	Protein[2]	Calcium[3]	Phosphorus[4]	Vitamin A[5]
Wintering beef cow	20	8.1	0.11	1.35	0.3
Nursing beef cow	26	17.8	0.20	2.38	0.45
finishing yearling steers	30	23.4	0.30	2.59	0.4
dairy cow producing 60 lbs/day of milk (3.5 % B.F.)	62	61.6	0.90	8.80	0.45

1. Based on cost of 2¢/lb of T.D.N. eg = hay containing 50% T.D.N. at $20.00/ton.
   or barley containing 75% T.D.N. at 1.5¢/lb.
2. Based on cost of 15¢/lb for digestible protein = barley at 1.5¢/lb or soybean meat at 5.8¢/lb.
3. Based on cost of 1.5¢/lb for ground limestone (38% calcium) or 3.9¢/lb of calcium.
4. Based on cost of 9¢/lb for calcium phosphate (19% phosphorus) or 47¢/lb of phosphorus.
5. Based on cost of 10¢ per 1,000,000 I.U.

Table B Energy Content of Selected Feeds

Feed	Digestible Energy (Kcal/lb) dry matter basis
barley straw	820
oat silage	1181
alfalfa-brome silage	1080
alfalfa hay (early bloom sun-cured).	1135
corn silage (well eared)	1400
barley grain	1660

Table C Relative cost of TDN and DCP in common feedstuffs

Feed	Cost/100 lb	% TDN	Cost/100 lb TDN	% DCP	Cost/100 lb DCP
Corn (in 24 ton lots)	3.50	80	$ 4.38	7.0	$ 50.00
Wheat ($1.00/bu)	1.67	82	2.04	11.0	15.18
Barley ($0.75/bu)	1.56	75	2.08	10.4	15.00
Oats ($0.55/bu)	1.62	68	2.38	10.4	15.57
Wheat shorts	2.75	71	3.87	13.0	21.15
Wheat bran	2.60	58	4.48	13.6	19.11
Linseed meal	6.50	71	9.15	29.8	21.81
Soybean meal	6.40	75	8.53	37.4	17.11
Distillers grains	5.60	81	6.91	20.0	28.00
Corn germ oil meal	3.00	77	3.90	15.2	19.74
Rapeseed meal	4.90	73	6.71	32.3	15.17
Molasses (beet)	3.30	60	5.50	3.5	94.28
Beet pulp	3.80	70	5.43	5.8	65.52
Dehy alfalfa pellets	3.70	55	6.73	15.4	24.02
Brewers' dried yeast	12.70	73	17.40	38.4	33.07
Urea	5.50	-	-	197.0	2.79
32% protein dairy conc.	3.00	55	5.45	24.0	12.50
Alfalfa hay ($35/ton)	1.75	53	3.30	11.9	14.70
Brome grass hay ($30/ton)	1.50	48	3.12	6.0	25.00
Wheat straw ($14/ton)	0.70	42	1.67	0.6	116.67

$$\text{Cost/100 lb of nutrient} = \frac{\text{Cost/100 lb of feed}}{\text{\% nutrient in the feed}}$$