Acid-Detergent Fiber (ADF)

Crude fiber may not be the best indicator of the adequacy of fiber levels for maintenance of fat tests. Experiments with lactating cows at Cornell University indicated that acid-detergent fiber (ADF) was superior to crude fiber when relating dietary fiber fractions to fat percentage. This test was developed at the USDA in Beltsville and is based on the analysis of plant tissue for its cell wall constituents (CWC) and cellular contents (CC). Digestibility of CC always is very high. However, digestibility of CWC depends on the amounts of lignin and cellulose present. This lignocellulose is insoluble in acid-detergent, so it is called acid-detergent fiber (ADF). As ADF increases, digestibility of a plant decreases. Since ADF represents a better defined component of feedstuffs than crude fiber and is easier to determine, it probably will replace crude fiber in the future as a measure of the potential of a ration for prevention of milk fat depression.

Protein and Protein Replacers for Dairy Cattle

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Introduction

The common standards for feeding dairy cattle in the U.S. and Canada are those based upon the 1971 edition of **Nutrient Requirements of Dairy Cattle** (NRC— ISBN 0-309-01916-8), or, the 22nd edition of **Feeds and Feeding** (Morrison, 1956—no longer in print; 9th edition, abridged of same work, 1962, is still available and contains same tabular material). The NRC data is based upon consideration of the amounts of crude protein and digestible protein for dairy animals of various ages, physiological status, and production, whereas the Morrison values are based solely on digestible protein, on the same considerations.

It is well-known that a lack of protein will depress performance of animals, and in dairy cattle a severe lack will lower not only the yield of lactating cows, but also will affect the solids-not-fat content of the milk. A large excess of protein, on the other hand, is not toxic but is uneconomical, particularly at present-day prices for protein ingredients (or their substitutes). A high level of protein may increase milk protei slightly, but does not increase milk yield, provide the animals already receive required minimal levels.

In general, the present NRC requirements for milk production furnish about 150% of the amount of crude protein in the milk. The Morrison standards are not set figures but give range values, and these are about 130-165% of the protein in the milk produced.

Personally, my belief is that calculation of needs on the basis of DP is far superior to a system based upon CP.

When considering protein requirements of cattle it is necessary to remember that well-fed dairy animals have the ability to store protein, particularly during the dry period, and then they are able to catabolize body protein stores to synthesize milk during lactation. Naturally, the degree to which this is done is dependent upon many factors, but it is of critical value when high-producing cows are incapable of consuming enough feed to meet both their protein and energy needs during early lactation.

Determining DP Needs for Lactating Cows

An overall consideration of the results of the more recent and also the older experimental results suggests that the amount of DP needed in the ration per pound of milk produced is **not** constant, but that it is greater at high levels of milk output than it is at low yields. The two most obvious reasons for this are: (a) she uses stored body protein for milk production, as mentioned above, and (b) the amount of feed she consumes per unit of time affects the digestibility of protein.

The effects of inadequate DP are manifested earlier in the lactation period of the high producer than that of the low producer. Thus, the dairy clinician, faced with a fair number of cows which peak too quickly, and have "short-time" lactations, should immediately determine the feed intakes of the cows. A lack of protein coupled with a lack of energy can be disastrous, but a lack of either will cripple the good cow's ability to produce according to her full genetic potential. Too often, field personnel fail to consider the protein problem although they may recognize the energy lack.

A consideration of the use of body protein to produce milk together with the effects of plane of nutrition on the digestibility of protein indicates that rations fed to cows of various productive abilities should contain the following:

Production level (305 day, 4%FCM, lbs.)	Dietary protein (% DP of protein in milk)
5,000	120-125%
10,000	145-155%
20,000	175-185%

The above figures would indicate that regardless of present feeding standards used, most truly good cows are being underfed on DP!

There is much less variation in the amounts of DP needed for the maintenance of cows as recommended by various authorities, and a figure of 0.6-0.65 lb./day of DP for the maintenance of a mature 1,000 lb. dairy cow is not unrealistic. Values for other weights can be quickly calculated by adjusting for metabolic body size from the above figure, and this is the general procedure in developing feeding standards or tables of nutrient requirements, once a "base" value has been established.

In addition to the needs of DP for production. and maintenance, pregnancy needs, and needs of heifers during the first lactation must be considered. In New York trials, the daily DP requirements for the development of the small dairy-breed and large-breed fetuses, respectively, were estimated to be 0.11 and 0.18 lb. during the sixth month, 0.3 and 0.5 lb. during the eighth month, and 0.4 and 0.6 lb. during the ninth month of pregnancy. These values are similar, but lower, than those estimated by a Danish scientist (Jakobsen).

Heifers are still growing, and therefore, they need additional amounts of both energy and protein when compared to mature cows of the same size. For protein, these needs are rather small, and a common recommendation is to supply about 0.25-0.3 lb. extra protein during the first lactation, and 0.13-0.15 lb. extra protein during the second lactation, in addition to the needs as outlined for maintenance, lactation, and pregnancy, in the feeding standard or table of nutrient requirements.

Feeding Standards vs. Tables of Nutrient Requirements

Some people have attempted to compare values as listed in feeding standards (such as the Morrison tables) with those as given in tables of nutrient requirements. Such comparisons should not be made. Feeding standards are intended to be practical, convenient *guides* to the proper feeding of various classes of stock. *They are not statements of the theoretical minimum requirements of nutrients, as given in the various NRC publications!* However, even professional nutritionists, who ought to know better, are still guilty of this sin.

Protein Value of Feedstuffs

Natural feedstuffs vary in composition greatly, even among materials described by the same class and type. For example, corn grain, on as as-fed basis, may vary in protein content from a low of about 6% to a high of about 12%, with an average value of about 8.8% total protein. Another factor complicating the evaluation of feedstuffs for dairy animals, and especially for high producing cows, is that most DP values for feed ingredients were obtained with beef steers or wethers which were fed rather limited rations. High-producing, liberally-fed, dairy cows simply will not obtain the DP values as listed in feed composition tables because they will digest a somewhat smaller percentage of the protein (and also most other nutrients as well).

Quality of Protein

When I went to college, I learned that one did not need to pay very much, if any, attention to the "quality" of protein fed to ruminants, including dairy cattle. Indeed, this statement is still largely true, *provided that* sufficient DP is supplied by rations containing forages and the usual concentrate feeds and fed only to cows of productive ability up to around 13-15,000 FCM/lactation. This statement is based largely on the fact that when urea, corn-grain proteins, and casein are fed to such dairy cows they all have a similar biological value (approx. 65%) for maintenance plus lactation. When fed to simple-stomached animals, only casein has a high BV and the other two have little or no value.

Recently, nutritionists have become much more concerned about quality of protein for high producing dairy cattle (those making more than about 15,000 FCM/lactation). When such cows consume large amounts of grain, as they must to sustain their production, roughage consumption falls, and the normal rumen environment is changed. Such rumen environments are not maximal for maximal synthesis of bacterial protein from NH_3 released by attack by microorganisms on soluble blood proteins. When the amount of NH_3 at a given time is too large, it will be wasted, and therefore, efficiency of protein synthesis is reduced. This is exactly the theory behind the present-day interest in protection of proteins by treatment with formaldehyde or other materials to prevent overattack in the rumen, and better, and later, digestion in the abomasum.

When the rumen environment is changed by heavy concentrate feeding, it may be necessary to supplement the ration with certain essential amino acids which may not be supplied in sufficient amounts either in the diet or by normal microflora activity. Such an example is the recent interest in the feeding of methionine or MHA in dairy cattle rations, which is claimed to help alleviate low fat tests and to help in the problem of ketosis. Variable results have been obtained by researchers, and indeed, one might expect this to happen if the cows used in the trials were of low or modest productive ability by modern standards. Personally, I feel that methionine or MHA has relatively little place in the ration of dairy cows unless cows are producing around 18,000-20,000 FCM/lactation or more. Thus, if it is used, it should be used on an individual cow basis, and not on a herd basis, and even then, it is not necessary to feed it throughout the lactation and dry period. A short period of feeding during the dry period, and during the peak of lactation, would appear to suffice and even so, variable results can be expected.

Another factor affecting the problem of protein quality for ruminants is that N-retention by cows fed legume-grass, hay-crop silage is much inferior to that of similar cows fed hay or hay-crop silage as the roughage. The N-utilization of low-protein hay-crop silages (less than 15% CP) is better than if the silages contain more protein. Some improvement in hay-crop silage protein utilization can be obtained by adding grain to the silage at the time of ensiling.

When one considers the statements made in the preceding paragraph and also considers the rapid proliferation of high-moisture or medium-moisture hay-crop silage structures in North America, one wonders whether or not additional DP should be fed to dairy cows consuming such forage. Certain statements have been made by suppliers of such structures that they not only preserve the harvested protein, but on an equivalent DM basis, crops harvested at the same time are of higher protein content. This statement may be true in many cases because of harvesting and storage losses in many other forage harvesting methods. But, if the utilization of protein is poorer than hay or silage methods, it makes one wonder about their real value as protein storage structures, other than labor-saving and ease of harvesting and unloading. High capital costs of such structures is also a negative point.

Using Non-protein N in the Dairy Cow Ration

Much more NPN is being fed to dairy cattle now than just a few months ago and, of course, the chief reason for this is the relatively high cost of natural protein materials and the relatively low producers' milk sales price.

A clear understanding of the limits to NPN utilization in dairy cattle rations is necessary in order to use it correctly and profitably. Dietary NPN is of little benefit to the ruminant unless it is converted first into ammonia, and then utilized for microbial protein synthesis in the rumen. However, there is a *maximal* concentration of ruminal NH_3 necessary for maximum microbial growth rates. An excess of NPN is wasted, is of no benefit, and increases costs.

Recent work from both Iowa and Wisconsin has outlined a new system of defining the protein requirements and values of various feed ingredients for dairy and beef cattle. This system is known as the "Metabolizable Protein and Metabolizable Amino Acid Values." These measurements can be defined simply as the quantity of protein or amino acid(s) absorbed in the post-ruminal portion of the digestive tract of cattle. Metabolizable protein includes the feed protein consumed which escaped degradation in the rumen plus the quantity of degraded protein that is re-formed into rumen microbial protein and a consideration is given to digestibility of the two sources of protein from each feedstuff consumed. Thus, metabolizable protein (MP) is *not* the same as DP.

This new system of evaluating protein requirements of cattle is very complex, and its application requires more calculations than a system based on either crude or DP. Tables have been developed to aid producers using this new method.

Ration composition has a vast effect upon ruminal NH_3 levels, as does also the crude protein level. Wisconsin research has shown that when ration level is above about 13% crude protein, more NH_3 is present in the rumen than can be converted to microbial protein, and that the maximal ruminal NH_3 level is reached quicker when low-energy rations are fed than when high energy ones are used. This is not surprising since work with NPN rations showed many years ago that high-energy rations were better for NPN utilization.

NPN can be used in dairy cow rations best when low-protein rations are fed which are high in energy. However, if one accepts the NRC needs as being the gospel, cows producing 45-65 lbs. milk/day should receive about a 15% crude protein ration with a ration (not concentrate) TDN value of about 65%, while cows producing above 65 lbs. of milk should be getting a 16% crude protein ration with 70% TDN (all values are based upon DM basis). If this is true, there is no way NPN can be used to meet the requirements of these cows, as the ruminal NH_3 level of NH_3 would not be satisfactory (low enough).

But, this is not the whole story by any means. As outlined previously in this paper, protein needs of cattle vary according to many factors. With the current high costs for protein, Wisconsin scientists recommend that cows in later lactation producing less than 50 lbs. of milk/day be supplemented largely with NPN sources so that total crude protein dietary levels are about 11-12% protein. For fresh cows and cows producing more than 50 lbs. of milk/day, however, *only* plant protein sources should be used to obtain protein levels of about 15-16%. It is granted in this type of recommendation that perhaps somewhat better results can be secured by feeding cows in later lactation more protein which would make the use of urea not possible, but cost-benefit analysis suggests that under present feed-milk price relationships this is the best course to follow.

This type of program immediately throws out the common method of feeding dairy herds by using one herd mix, but it seems that day when we could afford a common herd mix is over. The common herd mix program usually overfed the lower producers and usually did not supply enough protein for the high producers. If two grain mixes are not feasible, one could perhaps use a NPN-containing low-protein mix (in this case with about 11-12% crude protein from **natural** protein sources) for the late lactation cows, fully recognizing that the NPN would be of no value to the high producers and fresh cows. Then, he could topdress soybean meal at the rate of two lbs. for ever 10 lbs. of milk over 50 lbs.

The same principle includes the use of urea in corn silage. If urea is added at the time of ensiling, the common recommendation is to use 10 lbs./ton of green material. But, the high producing cow will not utilize this urea effectively and this forces the farmer to waste this urea unless he is prepared to feed two types of silage to his herd—one with NPN and the other without. Most are not prepared to do this.

A word about urea-based supplements is necessary. For palatability reasons, the urea level should not exceed 1.5% of a grain mix, and frankly, for most herds I prefer to keep the level below this. As usually recommended and done by most people, urea must be mixed **thoroughly** in the grain or silage. If silage includes urea, the urea level of the grain mix should be reduced in an appropriate manner.

Dairymen feeding much alfalfa hay or haylage will not be in a position to use any NPN, as their rations already contain about 12% or more of protein. They will continue to supply their high producers and fresh cows with all plant protein supplement and energy, vitamins and minerals as required. Fresh cows should be handled by all dairymen for at least the first 6-8 weeks of lactation as if they had the ability to produce 60 lbs. of milk, but from then on she should be fed according to production. Naturally, outstanding cows should be fed more concentrates than the average herd cow in early stages of lactation. Most dairymen make such adjustments as a matter of course.

Other sources of NPN have been used for dairy cattle, but the most common one by far is urea. Liquid ammonia is being added to silage, and, if this is done, the same limitations apply as with the use of urea. Biuret is not as satisfactory for producing dairy cattle as urea, although it is suitable for range beef cattle fed at least twice weekly.

Liquid vs. Dry Protein Supplements for Dairy Cattle

Liquid supplements are formulated by many and diverse formulae, and the actual composition of the supplements should be known to be employed at all effectively in dairy cattle feeding. Usually, liquid supplements contain all, or mostly all, NPN and little or no natural protein, and the same limitations of their use in dairy cattle as for dry urea-based feeds are necessary and important. Liquid supplements may use various sources of NPN such as urea (dry or liquid), mono- and/or di-ammonium phosphate, ammonium polyphosphate, and ammonium sulfate. My personal opinion about liquid supplements using these or similar NPN materials for high-producing lactating dairy cattle is not favorable in spite of some research reports to the contrary.

My chief objection to this type of liquid supplement for good dairy cattle is that when liquid supplements are fed to them, the consumption of other feeds is decreased. Thus, the total DM consumption is lowered (liquid feeds are relatively low in DM content) and for good cows this can be a serious matter. Also, for good cows the NPN contained in most liquid supplements would be of little or no value as explained above.

Table 1

Influence of Ration Composition on Mean Ruminal Ammonia Concentration and NPN Utilization

% CP in DM	% TDN in DM 55	60	65	70	75	80	85	NPN utilization
	--(mg/100 ml)--							(%)
8	6	5	4	3	2	2	1	
9	6	5	4	3	2	2	1	
10	6	5	4	3	2	2	1	> 90
11	6	5	4	3	3	2	2	
12	7	6	5	4	4	3	3	0-90
13	8	7	6	6	5	4	4	
14	10	9	8	7	6	6	5	
15	12	11	10	9	8	8	7	
16	14	13	12	11	10	10	10	
17	17	16	15	14	13	13	12	0
18	20	19	18	17	16	16	15	
19	23	22	21	20	19	19	18	
20	27	26	25	24	23	23	22	

Satter & Roffler (Wisconsin, 1973)

A hopeful development in the field of liquid feeding for good dairy cows was published recently by Kansas State scientists (Webb and assoc., 1973). A limited trial showed that a liquid supplement containing 60% cane molasses, 20% ammonium acetate (as NPN and energy source), and 20% water, did **not** depress consumption of other feeds when the liquid supplement was fed free-choice by lick-wheels. Using fairly good producers, greater milk production and body weight gain were noted from use of this particular supplement. In my opinion, however, the chief benefits from this supplement was **not** the NPN contributed by the ammonium acetate. Rather, the chief benefit was good palatability by the use of ammonium acetate and molasses, and part of the energy contributed by the acetate. This is because the dairy cow is an "acetate loving" animal!

Table 3

Upper Limit for NPN Utilization

% CP in DM before NPN	% TDN in DM 55-60	60-65	65-70	70-75	75-80	80-85
	--(% CP after NPN addition)--					
8	No	10.0	10.5	10.9	11.2	11.4
9	No	10.4	10.9	11.3	11.6	11.8
10	No	10.8	11.3	11.7	12.0	12.2
11	No	11.2	11.7	12.1	12.4	12.6
12	No	No	12.1	12.3	12.8	13.0

Slatter & Roffler (Wisconsin, 1973)

Table 2

Influence of Ration Composition on Efficiency of NPN Utilization

% CP in DM Before NPN	After NPN	% TDN in ration DM 55-60	60-65	65-70	70-75	75-80	80-85
		--(%)--					
8	9	0	25	53	81	90	90
8	10	0	24	48	75	89	90
8	11	0	13	37	61	82	86
8	12	0	7	22	39	60	71
8	13	0	4	14	24	37	47
9	10	0	23	47	74	88	89
9	11	0	12	33	60	81	85
9	1	0	5	20	38	59	70
9	13	0	2	10	20	32	45
10	11	0	9	31	59	80	84
10	12	0	2	11	34	55	69
10	13	0	0	6	16	30	40
11	12	0	0	6	33	54	68
11	13	0	0	0	9	22	36
12	13	0	0	0	3	16	33

Slatter & Roffler (Wisconsin, 1973)

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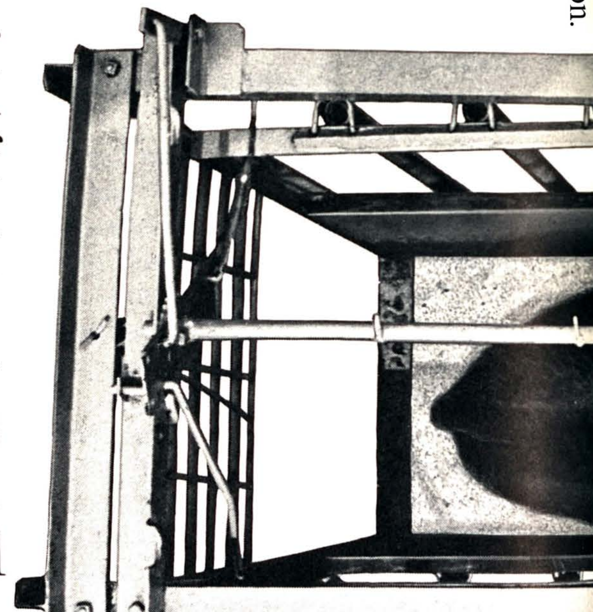

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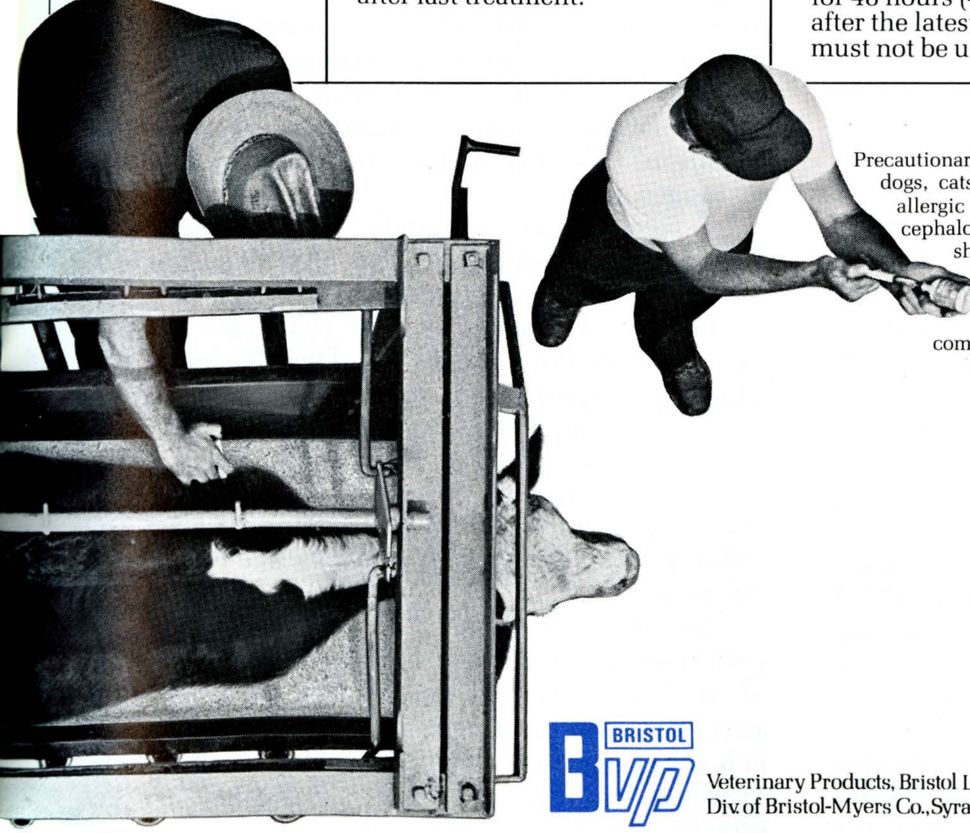

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