Proceedings

LIVESTOCK NUTRITION CONFERENCE

For
Virginia Department of
Agricultural Veterinarians

June 13 and 14, 1973
Virginia Polytechnic Institute
and State University
Blacksburg, Virginia

Sponsored by
The Cooperative Extension Service, VPI&SU
In Cooperation With
The Virginia Department of Agriculture and Commerce
and The Veterinary Science Department, VPI&SU

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. W. E. Skelton, Dean, Extension Division, Cooperative Extension Service, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

FOREWORD

A short course on animal nutrition was requested by the Regulatory Veterinarians of the Virginia Department of Agriculture and Commerce, Disease Eradication Section. Dr. A. J. Roth and Dr. W. O. Crutchfield, of the VDAC and Dr. S. L. Kalison and Dr. G. A. MacInnis of the Cooperative Extension Service, Extension Division, VPI&SU were given the responsibility for developing the program.

The short course was held at the Donaldson Brown Continuing Education Center on the campus of VPI&SU in Blacksburg, Virginia on June 13-14, 1973. This publication contains many of the papers presented at this short course.

The subject of animal nutrition is of great importance to all veterinarians in their efforts to control and combat animal diseases. The committee believes that the information presented in these papers will be of particular interest and help to practicing veterinarians.

CONTENTS

THE ROLE OF FATS AND CARBOHYDRATES

Dr. Scott Carr

In animal nutrition, energy is the primary contribution of carbohydrates and fats. In considering the economics of practical feeding programs, the provision of energy is the most costly aspect of feeding in that most rations require 6 to 8 times as much dry feed to meet energy requirements than is required for protein. Also, in animals fed for high production, energy is generally the most critical component since both physiological and physical factors limit energy intake. With other nutrients, the knowledge and techniques of feeding are available to meet requirements for different functions. However, this is not the case in our attempts to increase the energy that is available to the animal for productive functions.

The differences in the digestive physiology of monogastric and ruminant animals limit the feeds available for energy sources. With the monogastric animal, starch is the primary source of energy thus placing many of our domestic animals in competition with humans for available food supplies. Here the concern becomes the efficiency of conversion of energy to eggs or meat. In the case of the ruminant, with its ability to utilize cellulose, energy metabolism is not so much concerned with the efficiency of conversion, but with its limitation by voluntary intake. Cellulose is plentiful, but practical feeding is limited by how much cellulose of high-fiber feeds can be utilized and still meet the energy demands for high levels of production. In this sense, the efficiency of energy conversion is important, but in a manner different from that of the monogastric animal. Although the fermentation process and subsequent absorption by the ruminant host permits energy losses greater than the monogastric animal, the abundantly producing dairy cow is still a very efficient converter of energy, when measured as calories consumed versus calories returned in a form acceptable for human food.

The terminology employed in animal nutrition varies as to location and the species fed. In the United States, the total digestible nutrient (TDN) or net energy system (ENE) are prevalent. The TDN system is essentially the same as a measure of digestible energy or the two are highly correlated. The ENE system attempts to express the value of feeds for a productive function, i.e., milk production, growth, or fattening. Both systems have their limitations and the best one is generally determined by the function feeding is to serve. The major problem of the TDN system is that it overestimates the productive energy available in forages. For example, 100 lbs. of shelled corn contains 80 lbs. TDN and 80 therms ENE, while 100 lbs. of wheat straw provides 41 lbs. TDN and only 0-10 lbs. ENE. With the ENE system, accounting for heat production presents problems in that animals maintained in a cold environment make use of this heat. In a warm environment, the increased heat production is a liability. Recent improvements in classification of feeds for different functions have improved our application of feeding standards, however, both systems can be employed in practical feeding programs if their limitations are understood.

Fats play an important role in energy systems since their heat of combustion is approximately 2.25 times greater than the carbohydrates. The difficulty of storing and their effect on ration palatability have restricted large-scale application to practical feeding programs. With cattle, and depending on the source of fat, rations containing more than

10% fat are conducive to digestive problems. Monogastric animals appear to have a dietary requirement for long-chain unsaturated fatty acids. The daily requirement and exactly which acids are needed is not clearly understood at the present time. Diets practically devoid of fat can cause skin problems in swine. Practical rations for both monogastric and mature ruminants should contain approximately 5% fat, but this is an arbitrary figure.

The role of carbohydrates and fats is important in practical animal feeding and much remains to be learned about their functions, metabolism, and how to gain maximum benefit from these compounds. As the world population increases, the competition for energy sources between humans and domestic animals will demand that more attention be given to the efficient utilization of carbohydrates and fats in animal nutrition.

VITAMINS

Dr. G. E. Bunce

Vitamins are chemically unrelated organic substances that are grouped together only because each is essential in the diet in minute amounts. Traditionally, vitamins are classified according to their solubility in water or fat solvents; and from the physiological standpoint, this property determines the patterns of transport, excretion, and storage within the animal body. The esentiality of vitamins for different species is a consequence of the ability of the species or its microbial flora to synthesize the vitamin from readily available precursors.

In the cell, vitamins of the B-complex function in catalytic roles as cofactors in specific metabolic reactions. Typically, they oscillate between two active forms and are continually recycled between these forms as they participate in the operation of metabolic pathways. An analogy might be an individual member of a "bucket brigade" transferring water from a pond to a fire where each member stays at one site but assists in the transfer of many gallons of water over a long distance. Vitamins in cofactor form, however, serve not only as acceptors or carriers of chemical groups, but they may also facilitate the cleavage or formation of chemical bonds by influencing the distribution of electrons within substrate molecules.

Coenzyme functions have not yet been discovered for the fat-soluble vitamins or ascorbic acid. The role of vitamin A as a visual pigment is well documented, but its precise effects upon growth and development remain obscure. Vitamin D acts more like a hormone than a typical vitamin in that it stimulates synthesis of a calcium-binding protein in the intestine, thereby enhancing calcium uptake. Vitamin K has a highly specific role in the production of prothrombin, a protein required in the blood-clotting process. Vitamin C is known to be necessary for the maturation of collagen through its participation in the reaction which converts proline to hydroxproline. The cellular role for vitamin E is currently an area of lively research.

Because of the nature of their biochemical functions, vitamins are required in minute amounts (usually no more, and often much less than, 50 mg/day for humans). The striking consequences of vitamin deficiencies and the dramatic recoveries which can be effected by their restoration in the diet have caused the lay public to regard them with almost magical awe. The purveyors of "health foods" find vitamins to be apt candidates as compounds which will enable humans and animals to perform in an exceptional manner and enjoy super vitality. It takes only a moment's reflection to recognize that once the vitamin intake is sufficient to meet the catalytic needs, the excess will provide no extra dividend and will merely be excreted. Vitamin supplements may be useful, however, in instances where environmental factors such as disease, stress, injury, toxins, etc., lead to malabsorption or stimulation of excretion or catabolism.

THE VIRGINIA TECH FORAGE TESTING PROGRAM

Dr. Scott Carr

Virginia's testing program was organized in 1962 with financial support provided by the Virginia Tech Extension Division. The basic objectives of the program are to improve the quality of forages and emphasize their proper use in feeding programs. To accomplish these objectives, emphasis is directed to improving the knowledge and ability of the producer to recognize the characteristics of forages that are necessary for quality control. The program is maintained on a no-cost basis to encourage participation. All ration calculations or assistance in developing feeding programs are provided through county extension offices.

Any discussion of forage testing is amiss unless forage testing is considered in the same context as "forage quality". In Virginia, the economic potential of our cattle and sheep industries is tied to our ability to produce sufficient amounts of forages and still provide adequate nutrition. To be more emphatic, when considering the economic aspects of our dairy, beef, and sheep programs, a highly productive forage program is only secondary to the productive ability of the animals. Forage programs must be evaluated in terms of resulting animal performance, i.e., milk production, gains, etc., and not on yields alone. Virginia has made great strides in recent years in over-all animal agriculture and a significant part of this increased production can be associated with improved forages and their use. This is the area where forage testing can be a valuable teaching method.

The forage test has different meanings, depending on the individual's needs. To some, it is check for toxic compounds and for others, it is a means of determining specific ration deficiencies. The area where the most benefit can be obtained is the test's use as a simple guide for improving rations and forage quality. Unless the producer is willing to direct his efforts to improving both his feeding program and the quality of his forages, forage testing has limited application.

Response to the program has been favorable and progress toward accomplishing the established objectives can be seen. Probably the most significant improvement is noted with corn silage production and quality. Understandably, this improvement is not due to forage testing alone, but the testing program has played a definite part. As silage quality improved, economic advantages have occurred in both dairy-and beef-fattening programs. However, as feed costs continue to rise, even more emphasis is needed on quality forage programs to maintain our growth in these areas.

Increase in Corn Silage Production in Virginia

	1962	1969	1971
Acres (000)	103	180	191
Proportion of samples (% of total)	42	56	51
Dry matter (%)	29.3	36.9	34.3
Crude fiber (% of dry matter)	24.0	23.9	26.5
TDN (%)	15.8	24.5	22.9
% samples testing below 30% DM	59	16	28
% samples testing between 35-45% DM	12	41	32

Corn Plant Analysis and Yields at
Harvest on Different Dates

Date	8-30	9-27	10-18
Dry matter (%)	30	43	50
Crude fiber (%DM)	20	18	18
Grain (% of DM)	32	49	46
Yield-wet (tons/acre)	33	27	19
Yield-dry (tons/acre	9.9	11.5	9.7

Yield estimates based on 20,000 plants/acre

Comparisons of Hay Quality

Year	1962	1971
Alfalfa		
Acres (000)	200	80
Proportion of total samples	16	2
Protein (% of DM)	18.4	16.7
TDN (% of DM)	58	56
Orchardgrass		
Proportion of total samples	3	3
Protein (% of DM)	12.4	10.7
TDN (% of DM)	61	59

PROTEIN SUPPLEMENTS FOR BEEF COWS

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Brood cows have traditionally received little protein supplement under Virginia management, primarily because hay of fair-to-good quality has been the dominant winter feed. With changing management and more emphasis on corn silage and poor-quality dry forages, the necessity of supplemental protein is apparent.

Feeding purchased feeds to beef cows is to be avoided for economic reasons unless there is reason to do so. Protein supplement self-feeders available to cows feeding on good-quality feeds usually contribute only to the psychological well being of the owner. Check the forage to see if it has enough protein before investing in supplements. The Forage Testing Laboratory at VPI&SU is available through your extension office for testing feeds cattlemen plan to use. A sample analysis will tell you if additional protein is needed and, if so, how much. Contact your extension agent about the testing program.

Some Feeds Require No Extra Protein: Summer pasture and green winter grazing (cereals) need no additional protein supplement. Legume hays, grass-legume mixed hay, and high-quality grass hays require no additional protein for brood cows. Grass silage and silage made from Sudan grass, millets, and Sudan-sorghum crosses all have sufficient protein. Recent laboratory analyses indicate standing fescue in winter contains ample protein to require no supplementation until late February.

Forages That Do Require Protein Supplementation: Forages with less than 5% digestible protein require additional protein and, in most cases, vitamin A. Beef cow forages in this category are low-grade grass hays, standing sorghum forage, corn stalks, grain straw, orchardgrass straw, broom sedge, and late winter dry forage grazing.

Carefully plan the winter feeding program based on calving time, kind, quality, and quantity of feed. Decide upon the amount of protein needed (if any), relative costs, and whether the selected material is economical and meets the management needs.

Kinds of Supplements and Management Systems:

LEGUME HAYS - Legumes offer an excellent source of protein for brood cows. Seven pounds of average alfalfa or ten pounds of red clover hay will provide half the protein requirement for a nursing brood cow.

Advantages - Legume hays can be produced on most farms with the existing equipment and overhead. Legume hays are almost perfect brood cow feeds from a standpoint of protein, minerals, and vitamins. Reduces cash requirement for protein supplement.

Disadvantages - Hay is costly and time-consuming, both in making and feeding.

RANGE CUBES - 20% to 40% crude protein. Can be fed on sod daily or every other day.

Advantages - Cattle are counted daily and feeding improves ease of managing. Range cubes can be formulated to have optimum TDN, protein, and other additives for the particular nutritional need. Can be oil meals or blends of oil meal and urea.

Disadvantages - Must be hand fed daily or every other day.

PROTEIN BLOCKS - Wide range of protein contents with both natural protein and non-protein nitrogen. Contains salt to limit consumption.

Advantages - Can be self-fed and does not require everyday feeding.

Disadvantages - Generally higher priced per unit of protein than range cubes or oil meals. Sometimes can be better fed in boxes or bunks to prevent waste.

LIQUID PROTEIN SUPPLEMENT - One of the cheaper sources of protein.

Advantages - Very convenient to feed brood cows and cattle being roughed through the winter. Tanks can be filled periodically by the feed company. Most of the protein equivalent is in the form of urea. Requires the least labor.

Disadvantages - Consumption is difficult to regulate, some cattle consume too much, others fail to eat enough.

BIURET AND MINERAL - Biuret closely resembles urea in chemical composition, is about 240% protein equivalent, tasteless and slowly available.

Advantages - Readily eaten by cattle and is suitable for once a day feeding.

Disadvantages - Not yet as available as is desirable. Can never be as low in price as urea. Not enough yet known about how it can be used.

OIL MEAL AND SALT - Used where cattle cannot be observed regularly. For brood cows, use a 30% salt and 80% oil meal mixture and adjust the salt content up or down to get desired daily intake.

Advantages - Can be self-fed and saves labor.

Disadvantages - Facilities for mixing are usually lacking on most farms. Salt adds to cost but supplies no nutrition. Plenty of water nearby is a necessity. Cattle are not observed regularly.

OIL SEED MEALS - Cottonseed, linseed, soybean, and peanut meals have traditionally been the beef cattle protein.

Advantages - Preformed proteins of the finest quality for brood cows.

Disadvantages - The cake form is generally unavailable on the East Coast and usually lacks additives such as vitamins and minerals. The meal form can be fed only on silage or in a feed bunk. Oil meals are usually higher in price than part urea supplements.

EFFECT OF CURRENT FEEDING PRACTICES ON DAIRY CATTLE HEALTH

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Housing Systems

Conventional Barns. The traditional system of feeding dairy cows in the East is to offer available forage free-choice in stanchion or tie-stall barns and supplementary concentrates to individual cows based upon age, body size, milk production, milk fat test, and gestation. The most serious limitation of this system has been the inability to predict the forage intake of individual cows. A considerable body of evidence is available to show that only a small fraction of the observed variation in intake of forage by individual cows can be accounted for by such variables as body size, stage of lactation, milk production, etc. Therefore, the precision with which grain can be allocated to individual cows is severely limited, even within feeding systems where precise individual grain feeding is possible (Coppock and Tyrrell, 1966).[2]

The use of tabular material and work sheets to arrive at concentrate requirements clearly demonstrates that the necessary assumptions, particularly the assumption of forage intake, govern the answer one gets. In effect, the concentrate allocations obtained are clearly the result of the assumptions inherent in the calculations. A slight change in assumptions may change the answers considerably.

Free-Stall Milking Parlor Combinations. As newer systems of housing and milking cattle have evolved, such as the free-stall milking parlor combination, new problems have arisen:

a) With increasing emphasis on cows-per-man-per-hour in the parlor and increased parlor automation, the time cows spend there continues to diminish. Therefore, cows do not have time to eat the grain they need during the time they spend in the parlor being milked. Newer developments in parlor automation can be expected to accentuate this problem. Newer milking systems may require the elimination of parlor feeding to facilitate cow movement.

b) The alternative has been to resort to some concentrate feeding outside the parlor which has often aggravated the problem of achieving a correct protein-energy relationship in the total ration eaten by cows at all production levels.

c) The use of high-moisture corn (HMC), especially in free-stall systems, further complicates and reduces the precision of concentrate formulation and allocation because the HMC is often fed in a bunk and protein concentrate is fed in the parlor.

Feed Preferences and Feeding Behavior

Forages. Although there is some evidence of a trend to the use of a single forage such as corn silage in dairy cattle production, there seems to be a much better argument for the use of a combination of forages in other areas of the world. The logic for this recommendation has been presented on several occasions (Coppock and Merrill, 1967).[3] A major point within the framework of this argument is that the great divergence in composition between these two important forages (i.e., the energy rich, but protein-and mineral-poor, corn silage versus the protein- and mineral-rich alfalfa) provides for a nutritionally complementary effect when these two forages are fed in combination. However, in traditional systems of feeding forages to cattle, they are offered separately.

Forage Preference Expression in Dairy Cows. - (Cornell Experiment)*. In one experiment at Cornell which involved feeding lactating cows corn silage (CS) and alfalfa grass hay (H) or CS and hay crop silage (HCS) in sequential offerings of about 12 hr. each, it became apparent that some variation in preference was occurring even though CS was limited to 40 lb/day and the other forage was fed ad libitum. A summary of the total forage dry matter consumed in 1 week showed that 14 cows offered CS and H ate 53% CS and 47% H. However, at least one cow ate 20% H and 80% CS and another ate 70% H and 30% CS that week. Of the total forage dry matter eaten by 12 other cows, 67% was CS and 33% was HCS. But at least one individual ate 53% CS and 47% HCS and another ate 94% CS and 6% HCS. Though offered only one forage at a time, the cows apparently waited for the forage they preferred.

This observation led to a subsequent trial designed to measure forage preference in a two-choice, split-manger comparison. Twelve cows were used in a latin square treatment sequence of three comparisons each during 4-week periods. The treatments were: (1) H:HCS, (2) H:CS, and (3) CS:HCS, with each forage offered in ad libitum amounts. Forages were rotated to the opposite sides of the manger at the beginning of each day to cancel visual or behavioral cues. Grain was fed according

* A more complete discussion of this topic can be found in the 1972 Proceedings of the Cornell Nutrition Conference for Feed Manufacturers.

to a recent feeding guide. When offered the H:HCS treatment comparison, H (as a percentage of the total forage dry matter consumed by the 12 cows) was 42%, with the remainder being HCS. The range in individual consumption of hay was from 5 to 62% of the total forage dry matter eaten. For the CS:H comparison, the group ate 55% corn silage with a range in individual consumption of 40 to 78%. When the 12 cows were offered CS and HCS, CS represented 45% of the total forage dry matter eaten but the range for individuals was from 15 to 82%. Therefore, the aggregate forage consumption by this group of cows gave no indication of the range in forage preference among individuals within the group. This was true even though each forage was excellent in quality as judged by visual observation, chemical analyses, date of cutting, dry matter content, and by the fact that the group ate from 40 to 60% of each forage in every comparison. Additional trials are needed with more cows, longer periods and with sequential as well as simultaneous offerings.

If concentrate formulation is based upon a group consumption of about equal amounts of CS and alfalfa, but individuals within the group have an option, then the CS lovers will be underfed with respect to protein, calcium, and several other nutrients, while the alfalfa lovers will be overfed on protein, calcium, and other nutrients. The opportunity to express preference for these forages may be a partial explanation for the fat-cow syndrome seen in a number of herds today.

Forages vs. Concentrates. It is apparent also that cows vary in their preference for forage vs. concentrates. This is especially obvious in early lactation when these two classes of feedstuffs are each offered at essentially *ad libitum* levels. This factor is partially responsible for the great variation seen among cows in susceptibility to milk fat depression.

The Fat-Cow Syndrome

A problem of increasing importance in recent years is that of cows approaching calving with excess condition. Veterinarians report that fat cows seem more susceptible to disorders at calving time, and respond less vigorously to treatment.

A recent study in Ohio[13] showed that cows which calved with excess condition, ate less during the 90 days following calving than cows in modest condition. This work supports field observations which also indicate that fat cows have poorer appetites than thin cows. This conclusion has implications in several dimensions.

a) Fat cows are probably more prone to develop ketosis.

b) A recent Louisiana[6] study showed that cows losing weight had lower conception rates (more services per conception) than cows gaining weight. This may help to explain why high-producing cows are often difficult to settle. It does indicate that, although the fattening cycle may be more efficient than previously recognized, one should still attempt to feed the cow in early lactation as much energy as she can safely eat in order to establish positive energy balance as soon as possible.

It is very important to keep the dry cows separate from the milking cows so energy intake can be controlled to prevent fattening. Hay (not necessarily top quality) can be used to maintain cows through the dry period until 2 to 3 weeks before calving.

Some cows are drying off with too much body condition especially when high levels of corn silage are fed. Therefore, cows in loose housing should be grouped so that energy can be restricted (probably by changing the forage to concentrate ratio) during the latter part of lactation.

Complete Feeds

Feeding systems which allow the expression of individual preference for feedstuffs offered separately have the inherent disadvantage that the ration eaten by individuals cannot be defined. This is a serious limitation in research trials but it is also an unfortunate limitation in herds with a high incidence of some disorder, because the ration eaten by the individuals with the disorder cannot be characterized. However, the problems associated with preference expression can be completely circumvented by blending the entire ration together including forages, concentrates, and mineral supplements, and offering cows only the mixture. This blended total ration is called a complete feed. Every bite eaten is a complete diet. Some of the advantages of complete feeds compared to conventional systems of feeding might be enumerated as follows:

1) No parlor grain feeding equipment is needed.
    a) This decreases parlor construction costs.
    b) There is less dust in the parlor.
    c) Milkers can concentrate on milking; more cows/man/hour.
    d) There is no delay in the parlor due to the inability of cows to consume their required grain.
    e) Cows stand more quietly and defecate less during milking.
    f) Cows move through the parlor faster.
2) There is less labor required for feeding.
3) Complete feeds in conjunction with group feeding permit greater flexibility in protein supplementation.

4) Free-choice mineral supplementation is unnecessary.

Less salt can be fed; less sodium buildup in the soil will occur if greater quantities of manure are concentrated on smaller areas of land. High concentrations of sodium apparently inhibit plant growth.

5) Experimental evidence is available to show that high production with complete feeds can be achieved.

6) Use of complete feeds permits precise definition of the ration eaten by all cows.

By characterizing the ration eaten by all animals, the obscure relationship between nutrition, metabolic diseases, reproductive disorders, etc., can gradually be untangled. Meaningful field experiments can be carried out in this context. Metabolic profiles as described by Payne, et al.,[9] should be especially useful.

7) Silages in a complete feed system serve to mask and dilute the taste of materials such as urea, which limits the acceptability of concentrate mixtures if included at more than about 2%. In addition, when a complete feed is fed ad libitum, cows eat numerous small meals throughout the day which increases the efficiency of urea use by reducing the ammonia peaks characteristic of urea rations fed twice daily.

8) The use of complete feeds with a silage base greatly increases the flexibility and minimizes the number and magnitude of restrictions which must be imposed in linear programming least-cost rations. Howard, et al.[7], at Purdue University, showed that sudden and drastic changes could be made in concentrate

formulation without affecting intake or milk production when the concentrate was blended with corn silage in a complete feed.

Linear programming can also be used to show which forages or combination of forages are most economical to produce on a given farm based on costs of production and yield of energy and protein (Noller, et al.[8], 1969).

9) Fewer digestive upsets are probably encountered when high levels of concentrate are fed because small amounts of feed are consumed throughout the day.

10) The process of ration formulation for dairy herds is greatly simplified and the precision with which cows at all production levels can be fed nutritively complete diets is greatly increased through the use of complete feeds in which the ingredients are weighed or measured.

Some disadvantages of complete feeds include:

1) Special equipment may be necessary to thoroughly blend the ingredients.

2) There is little experimental evidence available now to provide precise guidelines as to the number of groups needed within a herd or the manner of formulation which will result in the most efficient use of concentrate.

3) It is awkward to use baled hay efficiently.

4) Grouping requires additional facilities.

Should cows be grouped? Even if it can be shown that cows will eat to approximately meet their energy requirements, there may be several reasons to group cows by stage of lactation.

1) Cows in early lactation probably warrant special formulation

with a higher protein level, for example, than cows able to meet their dietary energy requirements. The number of high-producing cows which fit this category is increasing.

2) When energy and protein in forages are less expensive than in concentrates, it is more economical to feed cows a high-forage diet in late lactation.

3) Certain features of management are easier if groups of 30 to 40 cows are maintained. One criterion of grouping might be gestation stage. Non-pregnant cows could be in one group, so that heat checking could be restricted to that group.

4) Dry cows should be grouped separately because they have been shown to overconsume when offered complete feeds with forage-concentrate ratios appropriate for lactating cows.

5) Delayed conception results in long calving intervals. Stale cows may overconsume and become over-conditioned before their dry periods in a one-group system.

6) The efficiency of feed use is probably higher in lower-producing herds that are grouped by production levels because energy concentration in the ration can be used to limit intake.

Discussion

Conventional systems of feeding dairy cows allow the expression of preference for feedstuffs which make up the ration. Great individual variation in preference exists among dairy cows so that the ration consumed by individuals under these conditions can only be grossly defined.

The cost of feed is the major operating expense of dairymen.

Quantitative formulation based upon least-cost analysis is necessary to minimize this cost.

Combining all feedstuffs into one mixture and offering only the blend (a complete feed) has numerous significant advantages over offering feedstuffs individually.

Research data are needed with complete feeds, particularly with respect to the ration parameters which affect voluntary intake. Research on continuing problems of dairy cattle production, such as milk fever, etc., will be facilitated by the use of complete feeds.

Protein

Browning Reaction. This reaction is due to heat damage which occurs when hay is stored with too much moisture and when hay crop silage is stored with too little moisture. The most obvious signs of heat damage are the brown color and the tobacco-like aroma which results from the browning reaction. The primary damage is due to binding of protein which renders it unavailable (indigestible) to the cow. A chemical estimate of this damage can be made by Van Soest procedures.

Hay crop silage should be within 50-70% moisture at ensiling.

EFFECT OF BROWNING REACTION ON PROTEIN DIGESTIBILITY[a/]

Forage	C.P.	Est. D.P.	Actual D.P.
	%		
Grass-Legume	17.3	13.3	8.3
Grass-Legume	11.1	7.1	3.2
Grass-Legume	16.7	12.7	8.5
Corn Silage	8.0	4.0	2.0

[a/] Dry Basis - Cornell University, 1971.

<u>Urea - Continued Controversy</u>. The cost advantage associated with urea use in feed formulation is the only explanation for the continued increase in the tonnage of urea being included in both dairy and beef feeding. However, the use of urea remains controversial in some circles primarily because most health disorders in cattle have at some time been attributed to the presence of urea in feed. In fact, nitrate is the only thing which ever replaced urea (and only temporarily) as the favorite "scapegoat" in feedstuffs. Of course, at high levels of intake, urea is toxic because of the rapid release of ammonia which occurs when urea is degraded by the enzyme "urease" present in rumen fluid. It is appropriate to recall, however, that many required nutrients are also toxic if fed at very high levels.

Although many experiments have been reported on the use of urea and few, if any, have implicated urea in the occurrence of health disorders, one can question the validity of most urea experiments to evaluate this question because they have been short trials, i.e., less than one lactation. Recently, a progress report was published from the University of Illinois[1] on the first phase of a long-term urea study. Holstein heifers, 12 to 20 weeks of age, were assigned to either a control ration (no urea - soybean meal) or a low level of concentrate urea of 1.6% or a high level of concentrate urea of 2.4%. Corn silage was the forage offered. At 2 years of age, the heifers fed the urea rations had eaten slightly, but not significantly less, dry matter and were essentially equal to the controls in terms of wither height, heart girth, and body weight. Further reports of this work should be especially helpful as reproductive performance and milk production data become available.

Last year, Michigan workers[10] reported the effects of feeding urea in DHI herds over a 5-year period on their reproductive efficiency as shown by calving interval and the percentage of cows sold for sterility. There were 3,157 herd-year observations and 85,281 calving-intervals calculated from records available at Michigan State. Neither the presence of urea nor the level of urea fed had a detectable influence on calving interval, percentage of cows sold sterile, or milk per cow.

Admittedly, the evidence of any urea involvement in health disorders based upon long-term studies is very limited. The information now available does not implicate urea in any form of health disorder when it is fed at recommended levels; nor is there evidence to suggest that a low level of urea and a low level of nitrate might have some additive effect which would be adverse.

As more dairymen move to complete feeds which are mixtures of concentrates-plus-forages, the problem of urea palatability will diminish because silages appear to reduce the taste problem of urea often encountered in milking parlors. Complete feeds will also make it possible to specifically identify the nutrient composition of the ration eaten by each animal. Although more long-term results of urea fed cows are needed, at this point there seems to be no solid evidence implicating urea as a culprit in the occurrence of health disorders.

All Silage Forage Programs

Corn Silage. A liberal-grain experiment, begun in 1964 in the animal science department,[12] included a treatment group of 10 cows that received corn silage as the only forage for three consecutive lactations. Within this group, 10 cows completed the first lactation, 6 completed the second lactation, and only 1 cow completed the third lactation.

The reasons for the losses were: (1) one for failure to reproduce;

(2) three died of mastitis; (3) one became paralyzed as a result of a spinal tumor; (4) one died of salmonella infection; and (5) the cause of death in the remaining three cows is unknown although postmortem examinations were made.

In a follow-up experiment, involving all silage forage, problems of heat detection and conception during the second lactation were more prevalent in those cows fed all-silage forage.

In effect, we do not have the problem of all-silage forage programs fed year-round solved at this time. At this point, farmers are advised to feed at least some hay to their dry cows, if pasture is no longer used.

Lead Feeding - How Valuable Is It? Lead feeding is defined as the practice of increasing the grain offered to a prepartum cow, beginning about 3 weeks before the predicted calving date, to a level of 1.5% of body weight by the anticipated calving date. This technique seems to have evolved about 12 years ago following the realization that many cows had the ability to respond to additional energy in early lactation with substantial increases in milk production. It seemed very reasonable at that time to use lead-feeding prepartum to facilitate adjustment to higher levels of grain-feeding postpartum. Consequently, lead feeding is now a widely recommended feeding practice. However, it is important to recognize that the value of lead feeding was not experimentally proven, apart from higher-grain feeding following calving.

Now, at least two reports have been published which question the value of lead feeding -- if cows are in good condition at drying off and are fed high levels of grain following calving. The following data illustrate the results of one of these studies.

Effect of Energy Level Prepartum and Postpartum on Milk and Milk Fat Production[1/]

Energy Level	Milk	Milk Fat
	---lbs/lactation---------	
Low - Low	12,346	427
Low - High	15,437	496
High - Low	13,719	465
High - High	14,405	465

[1/] Gardner[5] - 1969.

The low-and high-energy levels refer to pre-and post-calving, respectively. It is apparent that the low - high energy sequence resulted in the highest milk production. At this time several points which relate to lead feeding seem worth mentioning.

1) Recent trials show no milk production response to lead feeding if cows are in good body condition at drying off and are fed high levels of energy following calving.

2) In effect, it is now recognized that, although many cows lose body energy in early lactation because of inability to eat enough feed to meet their energy requirements, it is more efficient, energetically, to replace these reserves in late lactation rather than in the dry period.

3) High levels of grain near parturition have been shown to increase the occurrence of displaced abomasum. It is not clear whether high-grain feeding prepartum or postpartum is most responsible. However, we do have a choice in feeding high levels of grain prepartum but probably no reasonable alternative postpartum.

4) A good case can still be made for some modest continuous level of grain feeding (4 to 6 lb. per day) through the dry period to retain adaptation to the type of grain which will be received following calving.

5) The rapid increase in grain feeding before calving, which occurs with lead feeding, depresses forage intake severely both before and following calving.

6) Energy consumed by the dry pregnant cow, in addition to that needed for maintenance plus pregnancy, can only be deposited as fat. Enzyme systems of the cow which serve in fat deposition are not the same as those which function in fat mobilization. Lead feeding may be increasing stress on the cow at calving by gearing the enzyme systems to fat deposition when immediately following calving the cow usually must mobilize energy to support milk production.

Displaced Abomasum - Nutrition is Implicated

In a study carried out at Cornell on the use of high-grain feeding,[12] cows on restricted forage intake and high concentrate had a higher incidence of DA than those fed modest levels of grain with forage free-choice. Those on all-corn-silage forage also had a higher incidence of DA.

An experiment recently described in California,[11] showed 11 cases of DA in 46 cows fed a complete feed _ad libitum_ of 40% alfalfa hay - 60 % concentrate beginning 4 weeks prepartum; eight of the eleven displacements occurred within 2 weeks postpartum.

In another complete feed study reported from Purdue,[4] 40 Holstein cows were assigned 28 days before expected parturition to four complete feeds with: 1) 75:25; 2) 60:40; 3) 45:55; and 4) 30:70 forage to concentrate ratios, all expressed on a dry basis. During 25 days postpartum, there were 0, 2, 4, and 4 cases of DA in the four ration groups, respectively. In addition, of the 10 cows with displaced abomasum, 9 had a concurrent or previous disorder of some type such as metritis, retained placenta, etc. Consequently, both basic and applied research data have shown a relationship between the level of grain in the diet near parturition on the incidence of DA. However, it is difficult to distinguish between the effect of high-grain feeding before calving versus high-grain feeding following calving from these studies. Nevertheless, it appears that many of the cows which encountered displacements following parturition were never completely on feed after calving, so that some condition prepartum or at partum was at least partially responsible for the disorder. Although it seems imperative that we feed high levels of grain post-calving, we do have some choice about grain feeding before calving.

No doubt some current feeding practices are responsible for some of the increased occurrences of major disorders in dairy cows. However, newer systems of feeding cows, in turn, are helping reduce the stress of high-energy intakes necessary to support high milk production required in today's dairying.

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LIQUID SUPPLEMENTS FOR RUMINANTS

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The use of liquid supplements is not new in livestock feeding. In a sense, molasses may be considered a liquid supplement, and it has been fed to livestock for quite some time. The interest in liquid supplements in the past few years has been as replacement to dry protein supplements. More specifically, liquid supplements are used mainly as carriers of urea which is used as a partial protein replacement in ruminant rations. Of course, the supplements contain other nutrient entities.

It is well established that cattle and sheep can use urea to replace part of the protein in the ration. The rumen microorganisms are capable of converting urea into microbial protein. The microbes have certain nutritional requirements. Also, when urea is substituted for oil meals, certain nutrients supplied by the oil meals may become critical. These are important considerations in formulating high-urea supplements, whether in liquid or dry form.

Liquid supplements may be fed in different ways, mainly by mixing into the ration, "top dressing", free-choice feeding, and in drinking water. The largest volume of liquid supplement is used by mixing into the ration. It can be mixed in complete feedlot rations, creep feeds, or with roughages such as corn cobs, silage, green chop, or ground hay. Top dressing would mean spraying or pouring the liquid over the ration or roughage. This method may be especially beneficial for newly weaned calves which are not accustomed to eating out of feed bunks. Free-choice feeding is used mainly for cattle on pasture or on wintering rations. Care should be taken to prevent overconsumption. Inclusion of liquid supplements in drinking water is not a very satisfactory way of feeding the liquid supplements, especially since water intake will be quite variable, depending mainly on the weather.

A variety of components have been used in liquid supplements. Molasses is the main liquid vehicle used. Different kinds of molasses have been used but the main one has been blackstrap cane molasses. Urea is the main source of non-protein nitrogen used, but other sources, such as diammonium phosphate and ammonium polyphosphates are also used. The most common source of phosphorus in liquid supplements is phosphoric acid. Others include, mono-, di- and trisodium phosphate, ammonium polyphosphates, and diammonium phosphate. Advantages of the latter two products are that they supply both non-protein nitrogen and phosphorus. However, they are less concentrated sources of nitrogen than urea and of phosphorus than phosphoric acid. Trace minerals are included in most liquid supplements. It is the best if these are in the form of soluble salts. Most liquid supplements include vitamins A and D, and some include vitamin E and B-vitamins. Other components are included in liquid supplements, including antibiotics, drugs, ethyl alcohol, water, propylene glycol, and certain other minerals.

The primary nutrients in liquid supplements are nitrogen, readily available carbohydrates, phosphorus, trace minerals, and vitamin A. In some supplements, a fairly high proportion of the nitrogen is supplied in protein form. Readily available carbohydrates, phosphorus, and trace minerals are essential for efficient utilization of non-protein nitrogen by rumen microorganisms. Molasses is a good source of readily available carbohydrates and a fairly good source of trace minerals. Vitamin A presents a problem in that it tends to settle in liquid supplements. Settling appears to be a problem with diethylstilbestrol, also. The value of the B- vitamins is questionable since rumen microorganisms are capable of synthesizing these in sizable amounts. In other words, these do not normally need to be supplemented.

There is insufficient research data to fully assess the value of liquid supplements. In some of the experiments, the value of high-urea liquid supplement was compared to that of a dry conventional protein supplement. From data obtained in experiments in which the supplements were comparable, it appears that similar performance would be expected from cattle-fed liquid and dry supplements. For example, in an experiment reported by Purdue University researchers in 1967, daily gains were similar for cattle-fed liquid and dry supplements containing high levels of urea (table 1). Feed efficiency, expressed as pounds TDN/per pound of gain and feed cost per pound of gain were slightly in favor of the cattle fed the liquid supplement.

TABLE 1

LIQUID VS. DRY HIGH-UREA SUPPLEMENT

	Dry	Liquid
Initial wt., lb.	608	607
Daily gain, lb.	2.62	2.66
TDN/lb. gain, lb.	5.4	5.1
Feed cost/lb. gain	14.0¢	13.4¢

Purdue U. Res. Prog. Rpt. 303 (1967).

Many advantages have been claimed for liquid supplements. The main ones appear to be: 1) Improved palatability. Some of the ingredients, especially the molasses, may mask the undesirable taste of the more unpalatable ingredients. 2) Good urea utilization. The presence of readily available carbohydrates, phosphorus, and trace minerals would enhance urea utilization. Of course, these could be supplied in dry supplements. 3) Feed uniformity. By using soluble components there should be good uniformity of the feed. It is assumed that the ingredients will be thoroughly mixed. As mentioned above, however, there is danger of settling of some of the ingredients. 4) Reduced labor. If self-fed, labor may be reduced, as compared to a dry supplement. However, dry supplements can also be self-fed by using some material such as salt to limit consumption.

There are also some problems connected with using liquid supplements which should be taken into consideration. Some of the main ones are: 1) Lack of research data. Insufficient data are available from well-controlled experiments comparing liquid and dry supplements. 2) Over-consumption. The use of specially designed equipment is helpful. If it becomes a serious problem, one could use salt to limit consumption. However, there is no "fool-proof" safeguard against overconsumption by certain individuals in the herd or flock. 3) High viscosity. This may be a problem during the winter. 4) Settling of some ingredients. Some manufacturers recommend continuous or period circulation of liquid supplements. Obviously, such a practice would increase the cost. 5) Instability of ingredients. The potency of certain ingredients may decrease upon storage. 6) Equipment costs. If a producer has not been using liquid feeds, special equipment will be needed.

In summary, it appears that animals fed liquid supplements will perform similarly to those fed comparable dry supplements. The same precautions observed when feeding dry supplements containing high-urea levels should be observed when liquid supplements are fed. In determining whether or not to use liquid supplements, a producer should take into consideration all the economic factors.

NEW SOURCES OF PROTEIN FOR CATTLE AND SHEEP

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A rapidly expanding world market for protein sources for human consumption and livestock feeding has caused a tremendous increase in the price of soybean meal and other high-protein meals from plant and animal sources. Indications are that these high prices will probably recede following the soybean harvest of the present year. However, it is doubtful that these products will be as low in price as has been the case in the years preceding the present boom. It is imperative that the knowledge and practice of the use of non-protein sources of nitrogen be improved and expanded in the cattle and sheep industry. New sources of protein for ruminant nutrition must be avidly sought and rapidly adapted to production program.

An outline of presently available "new" protein sources may be presented as follows:

A. Non-Protein Nitrogen Sources

1. Urea (with grain or molasses)
2. Biuret (with minerals, grain or molasses)
3. Anhydrous Ammonia
4. Ammonium Chloride
5. Ammonium Polyphosphate
6. Ammoniated Feedstuffs
    a. Rice Hulls
    b. Molasses
    c. Whey
    d. Volatile Fatty Acids
    e. Citrus Pulp
    f. Beet Pulp

B. By-Products

1. Corn steep liquor
2. Ammoniated wood pulping liquor
3. Feather meal
4. Livestock wastes

Although the results of studies comparing the performance of cattle-fed urea versus plant-protein supplements are quite variable, the majority of these studies indicate a slight advantage for cattle receiving the plant proteins. However, when cattle have been adapted to urea prior to starting the trials and when a readily available source of energy is used, little difference in response to plant protein and the NPN supplements has been noted. Research at Minnesota and at Virginia Polytechnic Institute and State University has demonstrated that the majority of the difference is observed during the first 3 to 4 weeks of the feeding period. A summary of three Minnesota feeding trials showed that cattle previously adapted to urea performed as well as those fed soybean meal. Results of metabolism studies at VPI&SU confirm these findings. It appears that a change in urease activity is not a major factor in the urea adaptation response.

Several studies have been conducted comparing the influence of urea and biuret supplements in growing rations of cattle and sheep. The majority of these studies indicate that similar performance is obtained when either of the two is used; however, consumption or palatability of substances containing biuret has been generally superior to those containing urea. A growth trial conducted at the USDA to study ad libitum versus twice-daily feeding of these two nitrogen sources indicated that urea was slightly superior in terms of animal performance under ad libitum feeding conditions, but biuret was clearly superior under twice-daily feeding conditions. It should also be noted that biuret has a slightly longer adaptation period (4-5 weeks) than urea and is considerably more expensive.

Many questions have recently arisen concerning the influence of NPN sources, especially urea, on reproduction in cattle and sheep. In recent research at North Carolina State, the influence of dietary urea on reproduction was studied in a series of experiments utilizing 240 Angus and Hereford cows, 176 ewes, 4 Holstein bulls and 8 rams. Animals were fed conventional diets consisting of corn silage or low-quality hay supplemented with either urea or soybean meal. The amount of dietary nitrogen obtained from urea ranged from approximately 25% to 38%. In the cow and ewe studies, the incidence and regularity of estrus and percentage of females calving or lambing from service during one estrus period were not affected by dietary urea. Other reproductive characteristics apparently not affected by urea feeding were: fetal development, parturition, ovulation rate in ewes, subsequent fertility, calving interval, and cow and calf weight gains. In the male experimental animals, characteristics of fresh semen, as well as storage capacity of diluted semen from Holstein bulls were not affected by dietary urea. In rams, fertility as measured by percentage of ewes lambing from service during one estrus period, and lambing rate of ewes bred was not affected by diet.

Other NPN compounds used in cattle rations with varying degrees of success include anhydrous ammonia, ammonium-chloride, a gelatinized starch-urea product called starea, ammoniated rice hulls, ammonium salts of volatile fatty acids, ammonium polyphosphate, urea-celulose complexes, corn steep liquor, and several others. Some research records have reported an improvement in urea utilization when dehydrated alfalfa meal, distillers solubles, or fish solubles were added to rations containing these substances.

The feeding of liquid protein supplements containing non-protein nitrogen sources has received considerable attention during the last few years. In regard to the performance of cattle obtained with dry or liquid supplements, results have indicated that similar performance may be obtained with either kind of supplement. The system of choice largely depends on the economy of the supplement and the personal preference of the feeder. The possibility of the use of various labor saving devices may be a factor in the choice of whether to feed a dry or a liquid protein supplement.

By-products such as corn steep liquor, wood pulping liquor, and feather meal have proven to be satisfactory substitutes for protein in ruminant rations. However, palatability problems have been experienced with both pulp liquor and feather meal.

Recycling of livestock wastes such as chicken litter and feedlot refuse has received considerable recent attention. Recent work at VPI&SU has indicated that chicken litter can be utilized in ruminant rations and processing methods such as frying and ensiling have indicated very favorable possibilities for incorporating this material into livestock feeds. At present, feeding regulations prohibit the use of this material in animals subsequently marketed for meat. Recycling of livestock wastes has indicated a high nutrient potential from these materials and much future research is necessary in this area of nutrition.

USE OF NON-PROTEIN NITROGEN (NPN) IN RUMINANTS

J. P. Fontenot

How ruminants use NPN.

By virtue of the billions of rumen microorganisms, ruminant animals such as cattle and sheep are able to utilize non-protein nitrogen such as urea as a substitute for at least part of the protein in the ration. Ruminants can use urea as shown below:

Urea ⟶ Ammonia ⟶ Bacterial protein

↓ Digested

Amino acids
(Absorbed into the body and used to produce milk, meat, wool, etc.)

The bacterial protein which is synthesized is of high quality. The amino acids derived from this protein are used in the same manner that amino acids arising from feed protein would be used in the synthesis of milk, meat, etc.

Factors affecting urea utilization.

1. Nutritional factors important in urea utilization.

   For good urea utilization, the following nutritional conditions are important:

   a) Protein must be needed. If the protein content of the ration is already adequate, there will be poor urea utilization.

   b) There must be a good supply of readily available carbohydrates such as sugars and starch. This could be supplied in the form of such materials as molasses or corn.

c) Phosphorus.

d) A certain amount of trace minerals is essential also. These may be present in natural feedstuffs. If not, they should be supplemented.

e) Sulfur. When using a high-urea supplement, it is important that adequate sulfur be provided. Most of the high-urea supplements will contain sulfur added as such or contained in feedstuffs.

2. Adjustment of cattle to urea.

It is important that cattle be gradually adjusted to urea feeding in order to obtain good utilization of the urea and prevent urea toxicity. Dr. A. I. Virtanen from Finland has presented some work showing this very dramatically. He and his co-workers found that if dairy cows were gradually adjusted to urea feeding they could obtain fairly high milk production even when almost all of the nitrogen was supplied in the form of urea. Research workers at Minnesota and Purdue have also obtained results indicating the importance of gradual adjustment in order to obtain good urea utilization. Normally, in Virginia we have not observed differences between high-urea supplements and conventional protein supplements for fattening or wintering cattle. However, we have always gradually adjusted the cattle to urea.

High urea supplements.

Various research groups, including research workers from Virginia, have studied the value of high-urea supplements for cattle and sheep. Generally, the results have been quite satisfactory when using these high-urea supplements containing as high as about 100% crude protein equivalent. However, in these studies, generally the percentage of nitrogen coming from urea did not exceed the maximum recommended level of one-third of the total ration nitrogen.

Urea addition to corn silage.

Urea is recommended as additive to corn silage at ensiling time at the rate of 10 lb. per ton. At this level, crude protein content of silage will be increased by about 50%. Caution should be used in obtaining uniform distribution of the urea.

Precautions in using urea as a nitrogen source.

1. The animals should be gradually adjusted to urea.

   This is important for efficient urea utilization, as well as for preventing urea toxicity.

2. Adequate levels of certain nutrients needed for efficient utilization.

   The nutrients pointed out above should be supplied in adequate amounts.

3. The levels of urea in the total ration should not be too high.

   The urea should not supply more than one-third of the total protein equivalent of the ration.

Nitrogen (crude protein) content of urea.

Feed grade urea contains about 281% protein equivalent or crude protein. It contains 45% nitrogen.

The protein equivalent of 0.16 lb. urea is equal to that of 1.0 lb. of 44% protein soybean meal.

Other NPN sources.

1. Diammonium phosphate

   a) It is safe and effective.

   b) The protein equivalent of it is only 112 to 130% as compared to 281% for urea.

   c) It contains 20-23% phosphorus.

   d) Sometimes used in liquid supplements.

2. Ammonium polyphosphates

   a) Crude protein content of these is low, 56 to 59%.

   b) Used in liquid supplements, usually in addition to urea.

3. Biuret

   a) Contains 248% protein equivalent.

   b) Not attacked as rapidly as urea by rumen microorganisms.

      No danger from toxicity.

   c) Generally, results have not been consistently different than when urea was fed.

   d) More expensive than urea.

   e) Needs 3-4 weeks adaptation period.

   f) Promising with high-forage rations.