Cattle Feeding

Oklahoma Cattle Feeders' Seminar

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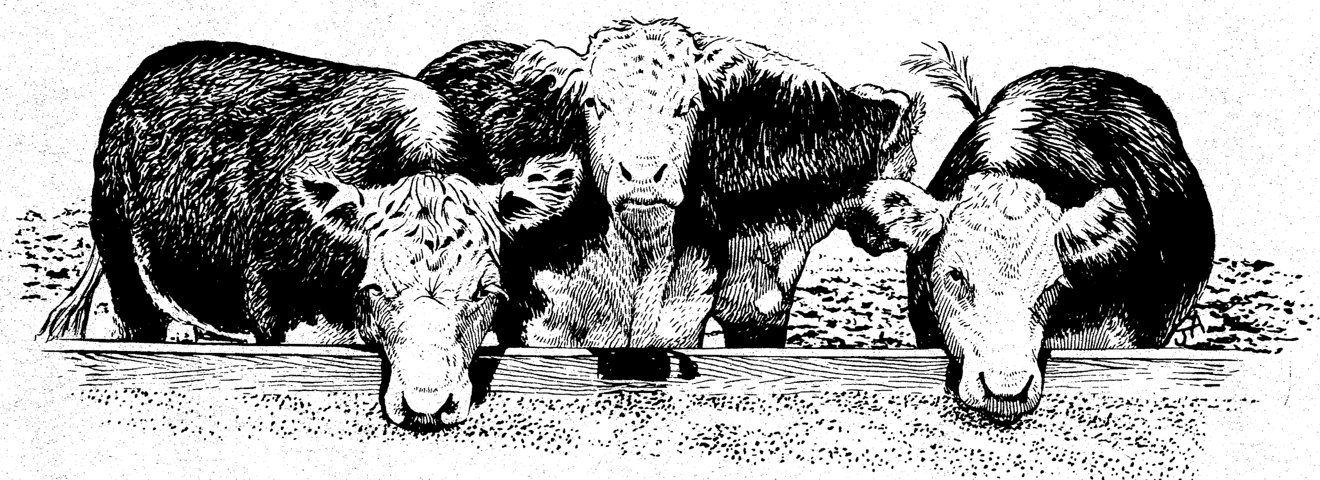

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FACTORS CONTRIBUTING TO THE RESPIRATORY DISEASE COMPLEX IN FEEDER CATTLE

by

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Part I - Health Related Practices of Western Cattlemen

The concept of preconditioning feeder cattle has aroused interest throughout the nation; no other program has generated more meetings, controversy and plans. The program which involves many facets, is designed to counteract the multimillion-dollar loss resulting from disease and mismanagement that occur at the ranch and between the time animals leave the ranch and arrive at the feed yard.

The preconditioning concept is comprised of recommendations for: (1) weaning calves on the site of production; (2) adaptation to a good ration; (3) vaccination against various diseases; (4) control of internal and external parasites; and (5) methods for transporting animals to the feedlot with a minimum of stress. Various segments of the industry have challenged this concept because documentation was not available. To obtain knowledge of the practices involved in handling cattle, questionnaires were sent to 1,246 ranchers in 14 western states. The survey involved 49,261 animals belonging to 341 ranchers who returned questionnaires.

Ranch Practices

Most of the animals weighed over 400 pounds when shipped. The majority (63 percent) were weaned at time of shipment; 23 percent were weaned 30 days prior to shipment. Prior to shipment, 12 percent were mixed with animals from other sources. For two weeks or longer, 15 percent were creep fed. Only 3 percent were implanted with stilbestrol.

Castration was performed on 9.38 percent of the animals 30 days prior to shipment. Only 0.29 percent were castrated 14 days before shipment; 53.34 percent were castrated within 45 days of birth. Surgery was used for castration of 53 percent of the animals. Of the 79.25 percent that were dehorned, 63.49 percent were dehorned within 45 days of birth; 12.24 percent were polled.

Vaccination Procedures

Considerable knowledge of vaccine usage was obtained from the survey. Of the 96 percent vaccinated for blackleg and malignant edema, 81 percent were vaccinated within 45 days of birth. Cowhands vaccinated 29 percent, owners 63 percent, veterinarians 2.48 percent, owner and/or cowhand 5.3 percent.

Only 7.7 percent were vaccinated for bovine virus diarrhea, with the veterinarian vaccinating 55 percent of these animals. Of the animals vaccinated for infectious bovine rhinotracheitis (21 percent), the owner and/or cowhand vaccinated 69 percent. Only 12 percent were vaccinated for leptospirosis and 13 percent for parainfluenza. Approximately 33 percent were vaccinated for burcellosis.

Other Data

Veterinarians sold 26,427 doses of the vaccines used, whereas 6,888 doses were obtained from farm supply stores, 15,317 from drug stores, 9,306 from wholesale houses and 1,995 doses from feed stores.

The survey also revealed that only 31 percent of the animals were treated for grubs. Antibiotics were given to 4.82 percent and vitamins to 27 percent.

Discussion

The survey revealed that preparation of the animal to withstand the stresses of movement to the feed yard is woefully lacking in the management program of many ranchers.

The majority of animals are weaned the day of shipment. This means that the greatest stress is ignored by most ranchers. The study showed 81 percent of the animals were vaccinated against blackleg under 45 days of age. Immunologists state that little protection is obtained against blackleg when animals are vaccinated at this age. Additional information gained from this survey revealed that most animals are not vaccinated for BVD, IBR, leptospirosis and parainfluenza before the time for shipment. Other preventive medicine and management practices aimed at reducing the stress associated with movement of animals are also largely neglected.

Cow-calf producers sorely need veterinary counsel if the preconditioning concept is to be implemented. The current objection from the rancher is that no premium is guaranteed for such animals. Demand by the feeder can quickly bring widespread use of the program into being.

Part II - Reducing Cattle Stress During Shipment

Many stresses are imposed upon cattle during movement to the feedlot. Many of the stresses and the resulting complications are controllable, but need the attention of both the cattle raiser and the feeder.

To define more clearly the problems of shipping stress, the authors conducted a survey on the movement of more than 125,000 head of cattle into Iowa feedlots during 1967. Where it was possible, cattle were traced back to the ranch or farm of origin, and the history of handling was obtained on the animals, along with their performance and disease problems in the feedlot.

Weaning

The survey added further evidence that weaning is one of the greatest stresses on beef calves. Animals normally will shrink 5 to 10 percent during weaning. Therefore, animals taken directly from their dams and immediately moved into the channels of trade are more susceptible to diseases and will suffer more severe consequences of stress than those that are weaned, allowed to regain their shrink and are "trough and bunk" adjusted.

Yet a study of shipments from producers shows most animals, especially calves are weaned just prior to or near shipping time. Out of 77 herds consisting of 11,440 animals, only 22 percent were weaned 30 or more days prior to shipment, and these were all yearlings. Only 3 percent of the shipments were weaned 14 days or more before shipping, and 61 percent of the herds were weaned at shipping time.

Records show many animals do not regain their shrink for 20 to 30 days when put into the feedlot.

Preventive Medicine

It is only logical to attempt to prevent diseases before they strike. This is reflected in the old adage about an ounce of prevention being worth a pound of cure. But the cattle industry has historically attempted to treat sick animals after they arrive in the feedlot. And some of the few attempts at preventive medicine appear to be poorly founded.

Programs designed to assure proper use of vaccines and chemicals for parasite control before the animals are shipped and before problems arise are just now being adopted. These programs to condition cattle to better withstand the rigor or movement are a must in disease prevention.

At the same time, promiscuous use and misuse of vaccines have caused some "lack of faith" in these biologics. Most vaccines are preventive and are not meant to be used on sick animals. Preventive medicines must be used properly, and this in many instances means that vaccines should be put into the hands of professionals.

Some of the problems in this area were revealed in the survey of cattle coming to Iowa feedlots. For instance, 91 percent of the herds, and 96 percent of the animals moving to Iowa feedlots in the survey, had been vaccinated for blackleg and malignant edema.

But in 70 percent of the herds, nearly 81 percent of the individual animals had been vaccinated within 45 days of birth. Protection is of short duration when the vaccine is administered at this age, so these animals had little or no protection from blackleg or malignant edema by the time they were in transit to Iowa feedlots. Only 7 percent of the herds had been vaccinated within 30 days before shipping; only 2 percent had been vaccinated within 14 days of shipment.

Historically, feeder cattle have been vaccinated after they have been subjected to stress by weaning and movement into feedlot. Preliminary studies of illness and death of cattle handled in this manner indicate these vaccines will provide better protection if used before the animals are under stress. Findings in the ISU survey also indicated this is true.

Direct Shipment

Animals moved directly from grower to feeder suffer less stress, are exposed to less disease and perfrom uniformly better than animals that travel through public cattle yards.

Generally, animals shipped directly from producer to feeder spend less time in transit. Nearly all the herds in the Iowa State University survey which had been in transit 24 hours or more had come through public sales yards. The influence of longer transit times was clearly shown in the survey.

Forty-five herds in the survey were in transit less than 24 hours. These herds included 5,564 animals, 232 of which later became ill (disease attack rate of 4.2 percent), and 33 animals died (0.6 percent).

Twenty-four herds were in transit 24 hours or more. These herds included 3,560 animals, of which 335 became ill (attack rate 9.4 percent), and 57 died (1.6 percent).

This indicates the disease attack rate for herds in transit 24 hours or more was more than twice as great and death losses were nearly 3 times as great as those in transit less than 24 hours.

These results strongly suggest that feeders should attempt to purchase cattle and have them shipped directly to the feedlot.

Age of Cattle

In general, animals over 600 pounds suffer less stress suring movement than younger or lighter animals. Calves present more problems than yearlings.

The survey showed that as weights of the animal increased, the animals were less likely to become ill, and the mortality rate was lower. However if heavier animals did become ill, they were more likely to die.

Accompany Cattle

For a multi-thousand dollar investment, it appears desirable for the owner or his representative to accompany his cattle to transit. In the ISU survey of 98 buyers, only 11 accompanied their cattle to transit.

The owner or his representative should see that conveyances are paneled and properly bedded, and that the animals are not over-crowded or exposed to exhaust fumes. If moved by rail, animals should be rested 12 hours after a 24-hour ride. If in a truck, a 12-hour rest after a 36-hour ride is recommended. Too often such management practices have been ignored.

Mixing Cattle

The survey showed a higher incidence of disease and greater death losses in groups of cattle assembled from different origins. In many cases, diseased cattle are mixed with healthy cattle. This is particularly true when small groups of cattle are assembled.

In the survey of feeder cattle entering one Iowa county, 60 percent of the herds experienced respiratory diseases, 35 percent of the herds experienced death losses, and of those herds with sick animals, 60 percent of them ahd heath losses. Average size of the county shipments was 127 head.

Shipments to a sample of Iowa's larger cattle feeders, averaging 380 head each, encountered higher illness and death rates. Seventy percent of these herds encountered illness, and 49 percent of the herds had deaths. Of the herds with illness, 70 percent had death losses.

This indicates that as the number of animals increase, there is a greater chance for disease exposure. Death and disease losses for animals which were traceable --- most of which were shipped directly from producer to feeder --- were lower.

Of the traceable herds, 58 percent encountered illness, and 33 percent had death losses. Fifty-seven percent of the herds encountering illness had death losses.

Looking at individual animals, in the shipments to one county: 8 percent of the animals experienced illness; less than 1 percent (0.97) of the animals died, and nearly 13 percent of those becoming ill died.

For the larger shipments, again 8 percent of the animals became ill, slightly less died (0.84 percent), and about 10 percent of the animals with illness died.

Of the traceable animals, nearly 9 percent of the animals became ill, but the death rate was lower than the other two groups (0.68 percent) and 7 percent of those becoming ill died later.

These results show our methods of handling feeder cattle are poor. The death losses of 1 to 2 percent of all cattle entering feedlots nationally is particularly distressing because most of the losses can be prevented.

The losses from shrink, poor feed utilization, improper drug use, and loss of gain is frequently hidden, but amounts to at least $10-20 per animal.

In the Iowa State study of more than 125,000 animals, 1,043 of these died or 0.8 percent. If the ISU sample is representative of all cattle feeding operations in the state, Iowa cattle feeders lose 31,616 cattle out of 3,952,000 grain fed cattle marketed in the state each year. At an average value of $150 per head, this is a loss of nearly $4 $\frac{3}{4}$ million.

Obviously, all death losses in cattle cannot be prevented. But it is likely that death losses could be reduced to about one-quarter of one percent or to about one-third their present level. This could save the livestock industry over $3 million per year.

There were more than 10,000 sick animals in the ISU survey. Again, if this is representative of cattle feeding operations, some 316,160 animals out of Iowa's nearly 4 million cattle on feed became ill.

Again, all losses due to illness cannot be eliminated, but the opportunity for reducing illness and costs is obvious. And these figures do not include money lost due to weight losses.

Summary

Stresses on cattle during shipment and the resulting dollar losses can be reduced if any effort is made by all segments of the cattle industry. These management practices can help greatly to reduce current losses to Iowa cattle feeders:

1. Have cattle shipped direct from the source of origin, if at all possible. A multi-thousand dollar purchase warrants some efforts on the part of the buyer.
2. Insist on pre-conditioned cattle with mandatory certification procedures. Such cattle are in limited supply now --- but won't be readily available in the future unless feeders ask for them.
3. Avoid buying cattle without knowledge of origin. This is like "buying a pig in a poke." (In the Iowa State survey of 98 cattle buyers, 70 said they knew the origin of their cattle, but researchers were able to actually trace about 10 percent of the animals purchased. Twenty-five of the buyers said they knew the vaccination history of the animals, 20 knew of the grub control measures used, and 28 said they obtained the feeding history of the animals.
4. Accompany cattle in truck or by rail if possible to see that rest stops are made and other good handling practices are followed. Frequently the profits of cattle feeding are made in purchasing and handling at this stage.
5. Have animals inspected by a veterinarian upon arrival and outline a treatment program. Don't wait until animals are sick.
6. The $10 to $20 hidden losses on each animal can be reduced. But you must act and establish a mutual understanding and partnership with the cattle producer to accomplish it.

Part III - The Movement of Feeder Cattle

During the Fall of 1967, three auction barns in northern, central and southern Iowa were observed from September 1, 1967 to January 1, 1968, a period of 15 weeks.

These barns were observed for methods of handling animals, source of livestock, clientele, and general method of operation. This report concerns itself primarily with the source of animals for these auction barns and the clientele purchasing animals from the barns.

During the time of observation, a total of 124,068 animals were sold by these barns. This averaged 41,356 animals per barn and 2,750 animals per barn per week. The animals were consigned in 6,432 lots, a 19.2 animals per lot average. (See Chart 1)

Source of Animals

Cattle consigned by ranchers and farmers directly to the barns numbered 810 lots and 11,745 cattle. This represented 12.6 percent of the lots and 9.5 percent of the animals. Known dealers of cattle consigned 5,622 lots of 112,323 cattle. This represented 87.4 percent of the lots consigned and 90.5 percent of the cattle. Those cattle consigned listing joint ownership of animals (grouped) numbered 636 lots of 23,199 animals or 9.8 percent of the lots and 18.69 percent of the animals. Lots of one animal numbered 1,581 or 24.5 percent of the lots and 1.2 percent of the animals. (S ee Chart 1)

Sales of Animals

Sales to the farmer feeder of animals amounted to 4,323 lots and 103,548 animals representing 67.2 percent of the lots and 83.46 percent of the animals. Bid ins and repurchases by dealers numbered 2,109 lots.

Discussion

The observations made upon these sales barns are not meant to represent all of this type of means of exchange. The type, variety and volume size of sales barns is too varied to be represented here.

In general, there are three basic types of auction barns in Iowa. The first is a local variety auction of low volume and a varied consignment consisting of a variety of species and certain other merchantable goods. The clientele is usually local. The second is the specialty barn in areas where cow calf programs and/or dairy programs are the mode of farming. The consignments consist of cull and slaughter cows, replacement heifers and calves. These barns will also sell other species during one day a week and during periods of low volume consignments will sell all species on a single day. The third type of auction barn acts as a meeting place for buyer and seller in areas where cattle feeding is the primary type of agriculture. These barns deal in replacement animals for the feedlot and are usually high volume barns, particularly so during the fall of the year when traditional restocking of feedlots begins. The clientele of these barns are primarily dealers in cattle, feedlot operators, order buyers of various types and abattoir representatives. The high volume and reputation auction barns attract clientele from many surrounding states in addition to Iowa. The source of animals for this type of barn appears to be the cattle dealer rather than the farmer. It usually is a larger operator with sufficient capitalization to purchase large numbers of cattle from varied points, assemble these animals and ship for 2 to 3 barns. These operators will usually furnish some animals from one barn to the other during the selling period. Shipping unsold or bid in animals to the various barns on the days they have their sales.

It is quite rare to find auction barn owners and operators listed as owners of animals sold in that barn although it has been established that they do indeed buy and sell animals through "front men". This same devious practice is uded for "bid in cattle" or those for which too low a price is bid for profitable sale. A single dealer may have as many as 5 persons "fronting" for him in the sale ring and clientele area. These "bid ins" may amount to as much as 60 percent of the total animals in the sale and average 32.5 percent of the lots sold and 16.5 percent of the cattle. (See Chart 2)

Grouping of small lots is a common practice of dealers and sales barn operators. These grouped cattle susally consist of repurchased cattle from previous sales, animals rejected by purchasers, ill animals that have been treated and recovered, and "bid ins".

Single lots of animals seem to be the greatest risk in auction barn purchases. These animals are rejects, ill and generally of poor type. Upon permission of the owner of one sales barn, all single sales were examined for illness. Of a total of 486 single sales in this barn, 305 were found to have a serious defect. The tentative diagnoses rendered in these instances were: infectious bovine rhinotracheitis, chronic bronchial pneumonia, bovine virus diarrhea, infectious keratitis, papillomas, lymphosarcoma, ergot poisoning chronic pleuritis, fracture of the femur, radius, thrid phalanx, separation of the scapula, malignant edema, infectious pododermatitis, vegetative pododermatitis, dilation of the esophagus, internal and external parasitisms, laryngeal edema, juvenile pregnancy, calf diptheria, malnutrition, and numerous abrasions, contusions and lacerations. These animals represent a total of 24.5 percent of the lots and 1.2 percent of the cattle sold.

Attempts were made to trace animals sold from sales barns to the final destination. This proved to an impossible task less than 10.5 percent of the animals could be traced. Records are not properly kept with attempts to trace seller and buyer highly confusing.

Identification of state of origin of animals is lost after the first sale and there remains no way to identify on a constant basis. Animals were consigned from 14 different states and one foreign country.

Conclusions

The method of handling, obtaining and selling animals in auction barns would seem to contribute to the respiratory disease complex in cattle; stale, stressed and diseased animals both perpetuate and perpetrate the disease complex. The problem of tracing animals remains the greatest puzzle in this method of marketing and identification of animals seems to be be all but impossible.

There is general laxity in enforcing existing federal and state regulations in identification of anomals moved from one state to another. Inspection of animals is perfunctionary.

Recommendations

1. More conscientious enforcement of state and federal regulations in identification of lots of animals shipped interstate.

2. Permanent identification of animals as to state and area of origin regardless of their economic roll on a national basis if shipped interstate.

3. Stringent enforcement of animal disease regulations in regard to the selling of animals with or exposed to infectious disease conditions.

FEEDLOT DISEASES AND DISORDERS - HOW TO SPOT AND TREAT THEM

by

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My subject encompasses a vast array of problems, any one of which is duly entitled to a complete presentation of its own. I am therefore going to discuss what I feed are diseases of "economic importance."

Last year, Dr. Collier discussed the role of Pasteurella multocida and P. hemolytica and their role in shipping fever. Since our existing anti-infective agents have little or no effect on viruses, we actually end up treating bacterial infections that may have been triggered by stress, virus, and then bacterial exposure.

It is for this reason then, that I classify feedlot diseases and disorders by the condition that they cause rather than by causative agent. The majority of our problems occur within the first 45 days in the feedlot. Respiratory conditions which account for 75-80 percent of our problems, generally require intensive care during the first 21 days at the feedlot.

Listing then conditions as opposed to diseases I list them as follows:

A. Respiratory - 75-80 percent
   1. I B R
   2. P I-3
   3. B V D
   4. PPLO (mycoplasma)
   5. Pneumonia
   6. Calf - Diphtheria
   7. Inter-mandibular phlegmon
   8. Salmonella
   9. Lung worms

B. Gastro Intestinal
   1. Diarrhea
      a. High energy ration
      b. Acidosis
      c. Salmonella
      d. B V D
      e. Coccidia
      f. Molybdenum
      g. Parasites
   2. Over engorgement - Acidosis
      a. Founder
      b. Bloat
      c. Impaction
      d. Entertoxemia

C. Miscellaneous
   1. Foot rot
   2. PPLO
   3. Brain involvements
      a. Listeria
      b. Hemophilus (T.E.M.E.)
      c. Polio - encephalomalacia
   4. External Parasites
   5. Internal Parasites
   6. Grubs
   7. Bullers
   8. Non-drinkers
   9. Urinary calculi

I hope to make this presentation as practical as possible in order that you can utilize whatever information may fit for your operation. All of the afore mentioned diseases of the animals respiratory system which starts at the mouth and nostril, and goes to the lungs, usually end up as one basic condition. This is called pneumonia which is nothing more than an inflammation of the lungs. Observation autopsies, and laboratory analysis by your veterinarian will differentiate the cause, whether it be I B R, P I-3, Pasteurella, etc., but you still end up treating the animal for pneumonia and/or other inflammations of the respiratory system.

Symptoms

What then do we look for? The incubation period for shipping fever is 2 to 5 days. Following this time the body temperature will rise to 104-108°F. In early stages the general attitude is seen at the time of, or just following, the morning feed. The affected animals will remain lying down or stand isolated with the head downward and outward. The hair will stand on end and the animal will move hesitantly. The eyes will have a dull-lack-lustre appearance, and ears will droop slightly. A clear mucus discharge will exist from the nostril initially. As the complex progresses the nostril will become dry and encrusted with dry exudate. The eyes show a profuse lacrimation (discharge) which becomes purulent pussy.

In several hours the animal shows a hollowness in area below the loin. Since they are not eating or drinking, they start showing weakness, depression and dehydration. Breathing now starts to increase in rate and coughing and open mouth breathing may prevail. Secondary diarrhea may occur which further accentuates the dehydration.

Treatment

In order for our existing armament of medications to perform, animals must be treated according to the symptoms that they show. There are 3 targets that we must attack in treatments:

1. Infection
2. Nutrition and water balance
3. Comfort and relief of pain (fever)

Infection

As I said earlier our sulfas and antibiotics afford protection or treatment against bacteria only. Any violent viral infection must be prevented if possible by vaccination prior to exposure to diseases such as IBR, BVD, and PI-3.

Dosages of various sulfas and antibiotics are as follows:

1. Penicillin - Streptomycin	3 cc/100 lb.	I. M.
2. Terramycin injectible	10 cc/100 lb.	I. V-I. P. -I. M.
3. Dihydrostriptomycin	2 cc/100 lb.	I. M.
4. Neomycin	4 cc/100 lb.	I. M. -I. V. -I. P.
5. Tylan 200	2 cc/100 lb.	I. M.
6. Sulfa solutions:		
12.5 percent	50 cc/100 lb.	I. V. -I. P.
25 percent	25 cc/100 lb.	I. V. -I. P.
7. Sulfa boluses:		
240 grain	1 per 200 lb.	orally
480 grain	1 per 400 lb.	orally

8. Bovine anti-serum:
Concentrated from blood of hyper-immunized steers for shipping fever complex. Use daily along with anti-infective agents.

Nutritional Therapy

Any animal showing dehydration has lost at least 3 percent of his body fluids. A 500 lb. animal with a 3 percent loss has lost 15 pounds of fluids or about 2 gallons. We have solutions containing 5 percent dextrose, amino acids, B Complex electrolytes. A common dosage is 500 cc (1 pint) to 1000 cc (1 quart) --- a far cry from the required 8 quarts. I prefer drenching cattle with 4 ounces of propylene glycol, calf milk replacer, $\frac{1}{2}$ ounce of electrolyte powder and 2 gallons of water. This can be done rapidly with a machine developed by one of our clients. I am convinced that a nutritional package which would contain a concentrated source of all essential nutrients for maintenance of a 500 pound animal for 24 hours is required. Such a formulation would, I feel, make our success at treating sick animals much better.

Comfort and Relief of Pain:

1. Cortico-steriods 1 - 2 cc/100 lb. I. V. -I. M.
    a. Reduce inflammation
    b. Release energy from liver stores
    c. Reduce fever and counteract shock and toxic conditions.
2. Antihistamines 2 cc/100 lb. I. V. I. M.
    a. Reduce fluid discharges in nostrils and lungs
    b. Founder
3. Amino acids, electrolytes, dextros solutions - 1 - 2 cc/lb. are best used for dehydrated and off feed cattle. Use this for bad cases with a follow up of oral drench of propylene glycol, calf milk replacer, electrolytes, and lots of water.

Intestinal - Diarrhea

Most diarrheas are associated with Salmonella or BVD infection --- many times a combination of both. Again our antibiotics have no effect on the BVD virus, so we treat the bacteria (Salmonella usually). Neomycin, Nitrofurazone and electrolytes in combination has given us our most effective treatment for infectious diarrheas. Injection of Neomycin (4 cc/100 lb.) is used for attacking any Salmonella that have invaded other body organs since intestinal absorption of Neomycin and Nitrofurazone is very limited.

Liquids or boluses containing astringent compounds are helpful, but are truly effective only after the infection is controlled.

Over Engorgement

This is a feedlot produced complication that can strike at any time. Sudden death, drunkeness, staggering, bloat, are all symptoms. Add roughage to the bunks for 3 days and then start back on concentrate rations with caution interspersing hay with mixed feed over a 3 day period gradually omitting all hay.

Treatment

1. Cortico-steriods - I. V. - to counteract toxins and shock.
2. Clostridium BCD antitoxin - I. V. - 50 cc.
3. Terramycin - 50 cc - I. V.
4. Drench or bolus of material to evacuate the upper intestinal tract such as mineral oil, epsom salts, soda or other preparations specifically designed for this use.

Remember

Antibiotics generally inhibit bacteria from multiplying, they don't kill them. The body white blood cells and other systems attack and destroy the now immobilized bacteria. To treat an animal one day, then let it go a day to see how it will do is not my theory of good practice. I treat all animals at least one time after the temperature becomes normal. This is to maintain a proper blood level of the agents we use and to allow the animals defense system to destroy the infective organisms that we have inhibited.

Naturally we all know that proper vaccination and management techniques may prevent many of our sickness problems. Still we have unpreventable problems which I have here discussed.

I trust that I have shed some light on treatment of these problems for you.

ECONOMIC TRENDS IN THE LIVESTOCK AND MEAT INDUSTRY [1/]

by

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The food industry from farm to the supermarket pushcart has been undergoing an explosive and dynamic revolution for the past two decades or more. Methods of production, marketing, processing, and merchandising have all been undergoing revolutionary change.

The consumer, through the chain and independent supermarket, is demanding higher quality, greater standardization, greater variety, and advanced packaging and presentation of product, all at lower prices. The number of products offered the consumer has multiplied more than five-fold in the past 20 years. New products appear, old ones disappear; competition for shelf and freezer space is brutally keen. To meet these demands, new relationships have sprung up among the farmer, the processor, and the retailer. These relationships are designed to maintain a steady flow of specified quality products from farm to retail display case to meet the preferences of discriminating consumers and to avoid out-of-stock situations.

The food industry, with its various ramifications, is the largest business complex in the United States. From within, it is an industry characterized by increasing unit size and decreasing unit numbers. It is rapidly becoming integrated and coordinated in the manner typical of many other large manufacturing businesses. Both chain stores and independents operate in a fiercely competitive market, which keeps margins of profits low, but which emphasizes the importance of volume as the key to success. The specifications required by the supermarkets have been a big influence in the move towards integration generally taking place in agriculture. It is within this dynamic setting of the total food industry that we must analyze the place of the livestock and meat industry and changes facing it.

CLOSER MARKET COORDINATION REQUIRED

Meat retailers today are in a position to specify what they want by way of animal type, weight, quality, cutability, and trim, rather than taking only what is sent to the markets. Demand at the farm and feedlot levels is becoming structured more and more in terms of a much narrower range of characteristics of the product which meet particular specifications. This means that closer coordination between the producer, the feeder, the processor, and retailers is required.

[1/] Talk presented at Oklahoma Cattle Feeders' Seminar, Stillwater, Oklahoma, February 6, 1969.

Many livestock producers and feeders are, and will be, evaluating possibilities for coordinating their marketing through contracting or other means in the next several years. Various forms of integration, which have been used by many nonagricultural segments to coordinate marketings, reduce risks, and assure supplies, are sometimes looked upon with disfavor by people in agriculture. They are fearful that freedom of decision will be lost. Nevertheless, the changing market structure and the requirements of mass distribution systems push with relentless pressure towards more regularity and dependability in the marketing machinery for all foods.

It may be trite to say that producers should become more market oriented, but this is a basic requirement. The first law of marketing is to produce and sell what customers want to buy, not to continue trying to sell what each happens to produce. Today, the need for products and their basic specifications must be determined in advance. Then, production and marketing should be geared to meet these needs so that demand can support a profitable price level. This is the type of sound business management that every well-operated business in America tries to follow.

TRENDS IN CONSUMER DEMAND

Now let us examine for a few moments some of the trends taking place in meat consumption and merchandising. Projections ahead for population expansion, consumer incomes, and meat consumption indicate that by 1980, total meat consumption will be at least 30 percent greater than it is today. Most of the increased consumption will result from population increases, since only a modest increase in per capita consumption is expected. U. S. population is expected to reach 245 million by 1980. We can assume that per capita consumption of beef will increase to around 115 pounds if consumer incomes continue at their present rate of increase.

Consumers will likely continue to favor beef over pork. Consumption of poultry meats will likely continue to increase, but at a slower rate per capita than during the past two decades. Lamb will likely have a hard time holding present per capita consumption rates.

If anticipated increases in consumer purchasing power continue, the following effects are likely:

1. A higher percentage of meat will be consumed away from homes in hotels, restaurants, and institutions, and these HRI buyers will continue to seek more services from their suppliers.
2. There will be a relative increase in demand for processed meat items as compared with demand for fresh meat. These products will contain more built-in maid services and conveniences.
3. Since incomes will be larger, there will be more money available for discretionary spending. It is estimated that over half of the disposable income will be discretionary by 1980. This will mean that more people can make choices as to how they spend their incomes, and they may be freer to change their whole style of life. Quality products with added conveniences will consequently increase in demand. This improved quality will influence competition among all kinds of meat. Price relationships among classes and types of livestock may thus be affected.
4. The major increase in population by 1980 will be in the age groups 30 years and younger. Younger people are the major consumers of hamburger and ground beef. Also, prices of hamburger are more in line with young family budgets.

If 70 percent of our beef comes from feedlots by 1980, where will major supplies for hamburger and various manufactured meat items come from? Will there be sufficient domestic slaughter of cow beef to provide supplies for this growing segment of the trade? Cattlemen will need to give consideration to supplying the domestic market for manufacturing meat, as well as supplying fed beef, or we will see rising pressures for more imports of boneless beef and veal.

ACCEPTANCE OF SUBSTITUTES BY CONSUMERS

Today's consumer is continually being presented with new food products. Breakthroughs in food processing technology have resulted in many kinds and varieties of new or noticeably improved products. Some are simply conventional farm products processed in new forms; others are synthetic or substitute products.

The market for livestock products, for example, has been heavily invaded by synthetics:

1. Synthetics have greatly replaced leather in shoes and furniture.
2. Synthetics have replaced natural casings.
3. Man-made fibers have cut into the wool market.
4. In 1952, margarine outsold butter for the first time; now per capita consumption of margarine is twice that of butter.
5. Synthetic detergents first outsold real soap in 1953. Now they represent 80 percent of the market.

Consumers like new products. New food items have strong appeal for consumers regardless of age, income, or education. Advertising has made consumers aware of choices among many competing products. Brand loyalty is becoming more limited and may last only as long as the customer cannot find something she likes better.

For centuries, eating habits resisted change. Technology in growing, harvesting, and packaging food was developing; but until recently, very little was done to alter the natural form of foods. Technology has changed all of that. Today, we have:

1. Formulated nutrition for weight control (Metrecal).
2. Instant breakfast products, such as nutritionally fortified mixes designed to be added to milk.
3. Synthetic fruit drinks of many varieties, along with other foods.

Science and technology have created new knowledge, new levels of aspiration, and new social pressures. These is more concern about excess calories and saturated fats----also, more interest in proteins, vitamins, and minerals. We are becoming more receptive to formulated, metered nutrition. Just as we have come to realize that our livestock and poultry grow and produce best from a balanced formula feed, some people are beginning to realize that human bodies may perform better on performance-tested foods. This may be a growing idea in America. It will have certain implications for the livestock industry.

Today, most families are considerably removed from the traditions of rural life and are thus more inclined to use the form of food product that best satisfies their needs. They do not care whether it is a traditional agricultural or a substitute food product. It is becoming more difficult to differentiate natural food from imitation. Food products must prove themselves on their own merits, quality-wise and price-wise. The battle against synthetics must be fought with performance, not words.

INFLUENCE OF SUPERMARKETS ON THE MEAT INDUSTRY

The concentration of food distribution into more chain store and supermarket type operations has resulted in fewer, but larger, market outlets for meat. Large packers, as well as small ones, are forced more and more to abandon their branch houses and traditional operations and must now negotiate the sale of large quantities of meat with large volume chain store and supermarket buyers across the table or by telephone. Such buyers must plan their programs well in advance; thus, there is more advance buying of meat and consequent arranging for slaughter livestock and feeder livestock all throughout the industry.

The share of the market handled by chains and independent supermarkets is likely to increase. By 1980, most of the meat will be purchased by some type of group buyer. Consequently, large retailers will be in a position to influence various factors, including price delivery terms, cutability, trim, and other terms of sale.

More meat will be bought on specification, and the specifications will be more rigidly enforced. Such a tightening of specifications will be primarily to reduce variability in quality, cut size, flavor, tenderness, etc., in order to assure the consumer "eating quality" that she can rely on.

With the growing aversion to fat, we can expect more retailers to require yield grading for cutability. Yield grading was a new term and a new idea to many people when it was introduced in June 1965. During the past three years, however, this new marketing tool for the meat industry is beginning to catch on. The percentage of beef slaughtered in federally inspected plants that is yield graded now exceeds 20 percent. The gradual increase in yield grading has resulted from the acceptance and use of yield grades by numerous meat packers and retailers throughout the country. Buyers and sellers of carcass beef are becoming more aware of the value differences between carcasses and are beginning to realize the importance of trading on the basis of both quality and yield grades. Reports of the U.S.D.A. indicate that most packers selling beef on a yield-grade basis have been able to obtain at least some price differentials between yield grades. Although these price differentials may be only $1.00 to $1.50 per hundredweight, and may not yet accurately reflect full value differences associated with differences in yields of retail cuts, nevertheless, they are an important step in the right direction.

More and more it is being recognized that there are wide differences in the cutability of cattle after slaughter, even though they may look very similar on a live basis when together in the pen. Yield grading is definitely a fairer way to determine the meat value of a carcass than the current practice of selling on an average price basis. When cattle are sold on the basis of an average price for the whole lot in the pen, those having high cutability are penalized to subsidize those carcasses having low cutability. Although it will take a lot of doing to work out all of the details for improved marketing using cutability grades, I believe we will see many more developments in the immediate future.

You all remember the old nursery rhyme, "Jack Spratt would eat no fat, his wife would eat no lean." Preferences have developed among consumers today which should bring forth a new nursery rhyme which might read, "Jack Spratt will eat no fat, his wife will eat none either, and so lean meat is all they eat, and fat is sold to neither."

As yield grading expands, we will see more production changes, particularly in the breeding and feeding of animals, to get a higher proportion having high cutability. With this development, it follows that the industry must give more attention to pricing aspects, so that producers who produce high-cutability animals will get the necessary premium for that production. This may mean considerable innovation in marketing practices and payment procedures.

Whether changes occur in favor of the livestock producers and feeder depends upon the imagination and united efforts put forth by them to bring about such changes. The old criterion of merit for a beef animal was confirmation or trueness to type. Perhaps this was satisfactory when farming and ranching were primarily a way of life, but it is not enough now that cattle are a different business in strong competition with other food businesses. The emphasis now must shift from eye appeal and color markings to development of muscling and more lean meat per animal.

Twenty-five years ago, we were taught "the eye of the master fattens the cattle." Now, we know that it is the feed nutrients that do the job and that the master might better be running his eye over feed costs, grade standards, conversion ratios, cut-out values, and the size of his calf crop. Sometimes, we have to shift our thinking from the past, however honored, to the future, however disturbing. If changes are called for, we will have to make them.

TRENDS IN MEAT PACKING AND PROCESSING

Time will not permit detailing the many significant changes that have taken place in the meat packing and processing industry during the past two decades. These changes have been influenced by developments in meat retailing, livestock feeding operations and transportation, rising cost structures, and general competition in the industry. Some of the major trends which have taken place and which are likely to continue are:

1. Decentralization of slaughter plants away from large terminal markets and location closer to supplies of fed cattle. This trend will continue largely as a result of cost problems:
   a. To get away from high cost at central terminals.
   b. To help solve complex labor problems.
   c. Because of obsolete high-cost, centralized facilities.
   d. To reduce excessive costs of transportation for cattle and/or meat products.

Figures show that those plants developing away from large terminals have better earnings. It is more economic to ship meat than feed or live animals under today's economic conditions.

2. There has been an increase in specialization of slaughter according to species, class, and grade. To meet the specifications of meat jobbers and the retail trade this trend will continue.

3. Many plants are being remodeled to streamline operations, utilize labor-saving equipment, and new processes to cut per unit costs and meet competition; and, also, to meet new Federal and State inspection and humane slaughter laws.

4. These is a continuing trend toward more deliveries direct to retailers from the packer. It may not be long before the wholesale cuts of meat will run through gangsaws at the packing plant, be picked up and

automatically packaged, loaded on pallets, and distributed to the retailer with much more efficiency than we have today. Many strategically located slaughter plants are including carcass-breaking operations and preparing primal cuts, vacuum packed for shipment direct to jobbers and institutional users, thus bypassing some of the traditional marketing agencies. This trend will likely continue in order to reduce costs.

5. Packers will seek lower cost methods of procurement through direct buying and other means. Forward contracting arrangements will be used more to reduce short-term fluctuations in volume of slaughter and to attain better control of raw material quality.

THE IMPACT OF CHANGES IN MARKET STRUCTURE ON THE LIVESTOCK PRODUCER AND FEEDER

It is becoming more apparent that cattlemen will have to fit their production and marketing to the needs of sophisticated consumers and adapt to better integrated marketing systems. The new developments in the beef business, namely chain stores, contract feeding, specification buying, etc., must be viewed in this light. New institututions that are developing in our modern industry are not the schemes of evil men intent on wrecking the cattle business; they are the innovations of people who are adapting to change to meet economic conditions. There may be those who would like to fight these changes, but in so doing, they may experience that same thing that happened to the dairyman who fought the milk inspector. He won the fight, but he lost his market. If changes are called for by demands of the market, we will have to make them to survive.

One writer has stated that farmers today divide into about four types:

1. The Innovators. These are the pioneers, the entrepreneurs, the forerunners of change. This group makes up less than five percent of the total number of farmers. They are not necessarily those that occupy the best economic position, since not all innovations are profitable. However, they are leaders.
2. The Adapters. This group makes up about 15 percent of the total, but they produce 60 to 70 percent of the food and fiber in America today. This is the elite group with which you are competing, the top farmers of today. These are the producers who are reaching ever-improving goals of efficiency.
3. The Imitators. This is by far the largest group. They are the ones who do not welcome change, but gradually wake up to the fact that if they do not change, they must go out of business.
4. The Losers. These have failed to become students of the present or the future, and they must eventually look elsewhere for a livelihood.

Cattlemen, along with other farmers, must recognize the need of accepting change. In the main, cattlemen have been at the forefront in adapting to change. They have increased their efficiency, lowered their costs, boosted their volume, and improved the quality of their product. They have done this, for the most part, without asking much help from the government. This record is a good one. It will be kept good only as the industry analyses and keeps abreast of what appears to be best for the future.

Some types of beef production that fit into modern market specifications and appear to offer opportunity for the future are:

1. The production of high-quality feeder calves with an earned reputation for high feed conversion capacity.

2. Production of 1,00 to 1,050-pound, choice slaughter cattle having a high ratio of lean meat to bone, high cutability, and produced on order or under contract.

3. Because of the need to keep procurement costs low and profits high, we may see increased production of crossbreeds and plain feeder cattle. The livestock feeder today likes small, healthy, thin animals and apparently under present marketing methods, this plain-type animal often can make more money than a so-called stock show, high-quality animal.

4. We are likely to see increased feeding of steers of dairy origin. More and more, we will find ways to turn male calves of the Holstein and heavy dairy breeds into higher-quality beef.

5. We may also see the development of feeding and fattening of young bull calves to weights of 1,000 and 1,100 pounds as a common practice. This is frequently done in Western Europe. Numerous research reports have shown that young bulls gain more rapidly and efficiently than steers and produce high-quality beef having more lean and good red color. Castration is a hangover from the past when the majority of steers fattened for market were long yearlings or older.

Many of these changes come slowly. New methods must be learned and long-established prejudices have to be broken down. Nevertheless, these may be developments for the future. The industry must keep its eye on providing the type of product which the consumer wants most, and hold back the day when vegetable-type meat substitutes, flavored to taste like meat itself, will claim a share of the consumer market. Cattlemen all down the line need to encourage every change that will help hold the share of the market that high-quality beef now has. We may see a bigger role for heifers, especially if current discrimination against them on price can be reduced. The number of heifers being fed this year is up over eight percent. Such developments might be good for the industry to keep housewives buying real honest-to-goodness beef instead of substitutes that lack the animal-source protein factor.

Direct marketing of livestock will continue to expand, and central markets will continue to decline in volume handled. There will be wider adoption of marketing methods that will reduce the amount of physical handling of livestock in making the transfer between the farm or feedlot and the slaughter plant. With fewer and larger producers and fewer slaughter plants, there will be less need for assemply-type markets. If this evaluation is correct, there will be a decline in the relative importance of auction markets as outlets for slaughter livestock. Auctions will continue to be important transaction centers for feeder cattle, cull dairy stock, and hogs.

THE LONGER-RUN OUTLOOK

In the long run, the outlook for beef is bright. There will be an ever-increasing market as population increases and as incomes go up. But the demand will be greatest for meat that has more flavor, tenderness, and carries less fat. Competition between areas of livestock production and feeding will be intensified. Also, competition between packers and retailers will be keen.

With the relative stability that we have in the national economy, the demand for meat week by week is fairly predictable. With adequate information as to animals on feed, along with predicted meat demand by weeks, coordinated efforts throughout the livestock and meat industry should be able to quite accurately determine the optimum rate of movement of livestock to market each week. This is one of the objectives of the American National Cattlemen's Association in its new program, known as Cattle Fax. Livestock men will be watching with much interest to see if more reliable information on the supply side can be developed and used to coordinate movements to market so as to avoid market gluts. Indications are that there is a firm economic base under an orderly increase in beef production in the next decade. It is when we overdo it on the supply side that the industry gets into trouble.

The problems which the livestock and meat industry face in the future are bound up in an interrelated package involving livestock producers, feedlot operators, meat packers, processors, and retailers. Each is an important segment of a large and complex industry. They are interdependent. Thus, what takes place in one phase of the industry has important implications for each other segment. It behooves each segment to make proper adaptations to recognized trends in the total industry complex if it is to remain competitive.

The basis for survival is good, sound management for the ranch, the feedlot, and the packing plant. Financial management will increase in importance. Financial management means the skill and discipline to properly budget and analyze the alternatives as a basis for improved business decisions. It also means the ability to exercise adequate budget and cost controls.

Today, the market for beef is world-wide and there are no favorites except those chosen by the customers. In marketing, as in other phases of life, the future will belong to those who prepare for it.

ARE WE OVERDOING IT?

by

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There is concern over the rapid rate at which cattle feeding is expanding in the Southern Plains area, the Panhandle and western parts of Oklahoma being included. The question of whether this growth is approaching a limit characterized by excessive feeding activity, low returns, and a cost-price squeeze is foremost in the minds of many Oklahoma cattle feeders. All feeding areas in the state, and indeed in the nation as a whole, are interrelated in a competitive sense and thus share in the concern.

Three factors are of primary importance in determining what geographical areas will survive and grow as centers of cattle-feeding activity. The three are (1) the cost and availability of feed grains, (2) the cost and availability of feeder cattle, and (3) the availability of markets for live cattle and carcass beef.

The analysis focused on an examination of these three factors. Although representative of the Southern Plains area as a whole, the analysis focused special attention on an area roughly in the shape of a circle with a radius of 100 miles and centered in Guymon, Oklahoma. The area includes the Panhandle areas of Oklahoma and Texas, southeastern Colorado, and southwestern Kansas. Conclusions concerning the three factors isolated for special attention might be summarized as follows:

1. Costs of feed grains in the Southern Plains area are as low as any in the nation, far lower than some competing regions such as the California-Arizona feeding area. Considering availability, examination shows the area around Guymon (as previously defined) produced enough feed grains to have ged an additional one million head of cattle in 1967. Even this does not appear to be a limit. Conservative estimates of irrigation development which is likely to occur in the area suggests yet another one million head of cattle could be fed in the area insofar as estimated feed availability is concerned.

2. Texas and Oklahoma rank first and second respectively in the production of feeder cattle. Oklahoma produces about 1.8 million head annually but fed only slightly over .4 million head in 1968. Many feeder cattle are being shipped into the state, with a substantial percentage of the reputation feeder cattle produced in Oklahoma being shipped out and fattened in other areas. Analysts agree that (a) more of the Oklahoma produced feeders will begin moving into feedlots in the Southern Plains area, and (b) the Southern Plains area, especially Texas and Oklahoma, will continue to lead the nation in the low-cost production of the feeder cattle. Neither the cost nor the availability of feeder cattle are likely to become serious limiting factors.

3. There are currently 15 federally inspected slaughter plants in the area referred to around Guymon. Eight of these have been cleared for federal inspection since 1965. These plants, and others are expected in the

area, provide an effective market for live cattle. The plants are increasingly able to compete in the rapidly growing beef market in the southeastern part of the United States, the Dallas-Fort Worth, Houston, and San Antonio markets in Texas, and to a limited extent in the West Coast market.

Overall, the analysis suggests the feeding in the Southern Plains area in general and in the defined area around Guymon in particular is not at a level which is approaching a limit. Feeding in the area around Guymon could be tripled without encountering serious problems in terms of feed grain availability. The area is sitting literally on top of much of the nation's supply of feeder cattle. Slaughtering plants are moving into the area and providing a ready market for live cattle.

While feeding could be greatly increased in the area, what will occur and how fast depends on the decisions made by feeders in the area and how fast adjustments between the major feeding areas in the United States will be completed. There will be a tendency for more feeding to flow into the areas with the greatest potential for cattle feeding and the Southern Plains area certainly falls in this category.

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SOME ECONOMIC ASPECTS OF WATER POLLUTION CONTROL FOR CATTLE FEEDLOTS

by

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The recent and rather rapid expansion of the fed cattle industry in Texas and other sections of the Great Plains has resulted in the concurrent development of a number of management problems dealing with solid and liquid waste that have broad social and economic implications. These problems are attributable to the high concentration and large number of animal units required for efficient feedlot operations. The most acute of these problems from the standpoint of feedlot operators is the potential of the feedlot as a source of water pollution.

Only a few years ago, designers of cattle feedlots on the Great Plains selected feedlot sites based primarily on two criteria: drainage and accessibility. Consideration of the drainage factor practically insured location on the nearest draw which in the absence of positive control measures made ultimate pollution of the surface water course a certainty. Today, a change in public awareness of pollution problems and a concurrent development in the attitudes and responsibilities of public agencies charged with enforcing anti-pollution laws have created an entirely new socio-political invironment. These latter factors coupled with rapid expansion of the industry and intensification of the problem have created a situation wherein prevention of water pollution has become a matter of serious concern to the fed cattle industry.

In the summer of 1966, the Cattle Feeders Division of the Texas and Southwestern Cattle Raisers Association requested research support from Texas Technological College on the problem of pollution from cattle feedlots. A project was drawn up and funded partly by the Association and partly by the Texas College and University Coordinating Board. Research responsibilities were subsequently divided among the departments of Agricultural Economics, Animal Husbandry and Agricultural Engineering at Texas Technological College. Although all of the departments worked cooperatively in the course of the research, the department of Agricultural Economics and the other two departments issued separate final reports. My paper today will be restricted to the research findings as contained in the report of the Department of Agricultural Economics.

Objectives

The general objectives of the study were to develop and determine the economic feasibility of various procedures or methods for controlling and disposing of feedlot runoff. More specifically, the objectives were:

1. To determine the quantity of runoff from representative feedlots under High Plains conditions.
2. To design procedures for controlling and disposing of runoff water from representative feedlots in the Texas High Plains.

3. To determine the physical and engineering requirements for alternative methods or systems of controlling and disposing of runoff water from representative feedlots.

4. To evaluate the economic feasibility of alternative methods or systems of controlling and disposing of runoff water from representative feedlots.

5. To develop and provide baseline data which would enable feedlot operators to select the most appropriate control and disposal system.

The first problem encountered in our study involved the determination of the quantity of runoff which would result from a given amount of rainfall. That is, the magnitude of the pollution problem as measured by the volume of runoff which must be controlled is a function of the amount of precipitation falling on the feedlot and that fraction which will become runoff. This latter quantity depends on the depth of the manure on the lot and its physical condition. When feedlots have a heavy, dry cover of manure, they will absorb considerable quantities of precipitation before runoff occurs. In contrast, for saturated lots, very little precipitation falls before runoff begins.

Because of time limitations on our study we were unable to set up the physical experiment to obtain primary data on rainfall-runoff relationships under High Plains conditions. We were, however, fortunate in that we were able to obtain the raw data from one such experiment conducted at Kansas State University.[1] Utilizing this data, an equation was developed to determine inches of runoff resulting from given inches of precipitation.

$$K = -0.3819 + .8732\,P \quad (1)$$

where K = inches of runoff
P = precipitation in inches

This equation served to explain 91.2 percent of the variation in runoff. From this point, it is a simple step to convert inches of runoff to quantity of runoff.

$$Q = R \cdot A \cdot 43560 \quad (2)$$

where Q = cubic feet of water runoff
R = amount of runoff in feet
A = acres of feedlot (pens and roads) and
43560 = square feet per acre

Collection Basins

A first step in controlling pollution from the feedlot is to minimize that amount of precipitation which will become runoff. Thus, diversion works on the perimeters of the lot are a must in reducing the magnitude of the problem to manageable proportions. A second step is to collect precipitation induced runoff before it can enter the natural drainage. The development of low cost and efficient structures (collection basins) are thus the ultimate basis of low cost pollution control.

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[1] Data supplied courtesy of Dr. R. I. Lipper, Department of Agricultural Engineering, Kansas State University.

The required holding capacity for any runoff collection system is a function of the quantity and frequency of precipitation, the total feedlot acreage contributing to runoff, the physical character of the feedlot surface and the acceptable tolerance with respect to periodic overflow.

Design capacities for the development of runoff collection systems in our studies at Texas Tech were based on rainfall data concovering a 41 year period. These data are specific for the Southern High Plains, hence, other areas experiencing different levels of precipitation and different rainfall frequencies would require different design capacities.

Rainfall data and equation 1 were used to compute the quantity of runoff flowing into each system, and given the size of each system, the resultant probability of everflow. Only rainfall amounts equal to or in excess of .44 inches was determined from equation 1. That is, when K (runoff in inches is equal to zero), P (precipitation in inches) is equal to .44 inches.

Collection basin designs were formulated on the basis of two distinct types of runoff control technology. The technologies and the resultant systems were termed "mechanical discharge systems," and "evaporative discharge systems." The former system involved discharge of accumulated runoff in the collection basin by pumping to one of two ultimate disposal areas. Design of the latter system, the evaporative discharge system, contemplated discharge of accumulated runoff in the collection basin by complete evaporation over time.

Mechanical discharge systems were disigned to hold the runoff equivalent of either 2, 3, 4, 5, or 6 inches of cumulative precipitation. In contrast, evaporative discharge systems were designed to hold the runoff equivalent of 12, 13, 14, 15, or 16 inches of cumulative precipitation. Collection basins for mechanical discharge systems have relatively small capacities as determined by the difference between the expected cumulative runoff and the discharge capacity of the pump. Design criteria for these systems assumed no evaporation losses due to shortness of the holding period. Similarly, design criteria for the evaporative discharge systems made no provision for seepage losses since it was assumed the collection basin would be self-sealing.

A measure of the degree of runoff protection afforded by either a mechanical or evaporative discharge system of a specific capacity is the number of overflows. Smaller capacity systems of either type will have a greater frequency of overflow than larger ones. Given the size of the system, frequency of overflow can be determined through analysis of historical rainfall data, assuming specific discharge and evaporation rates for the mechanical and evaporative discharge systems respectively.

<u>Number of Overflows - Mechanical Discharge Systems</u>

Three specific discharge rates of 0.2, 0.4, and 0.6 inches of rainfall equivalent per day were selected for each of the five sizes of collection basin. Overflow calculations were based on the holding capacity of the collection basin in terms of rainfall equivalents. Similarly, discharge rates are also stated in terms of rainfall equivalents, though at a latter satge, pumping costs were computed in terms of runoff equivalent or runoff actually discharged. For example, a 3-inch system has an actual holding capacity of only 2.2 inches of runoff since 0.8 inches will be absorbed by the feedlot (Equation 1). To simplify the overflow calculations, all systems including discharge capacities were stated in terms of rainfall equivalents.

The average number of gallons of water pumped from each collection basin was determined simultaneously with number of overflows. Gallons of water discharged were determined by summing the total inches of rainfall that occurred in amounts of over 0.44 inches, subtracting the total inches of overflow from the system, and dividing by the number of years, 41. In other words, if T is the sum of the quantities of rainfall in inches occurring in amounts in excess of 0.44 inches, and t is the sum of the rainfall equivalents in inches that overflowed the collection basin, then $\frac{T-t}{41}$ = average rainfall equivalents subjected to discharge.

Rainfall equivalents to be removed from the system by pumping are converted to inches of runoff by equation 1, $(K = -3189 + 0.8732P)$ and to gallons of runoff by equation 2, $(G = R \cdot A \cdot 27156)$.

The following example indicates the method utilized in computing the quantity of water discharged from each system given the quantity of overflow which occurred. The value of T for all 2 inch systems at a 0.2 inch discharge rate as derived from the 41 years of rainfall data amounted to 483.44 inches of rainfall equivalent. In the same 41 year period, a 2 inch system discharging from the collection basin at the rate of 0.2 inches of rainfall equivalent per 24 hours would have a total overflow t equal to 66.59 inches of rainfall equivalent. Therefore:

$$\frac{T-t}{41} = \frac{483.44 - 66.59}{41} = 10.17$$

In other 10.17 inches of rainfall equivalent to be removed from the system each year. Inches of rainfall equivalent were converted to runoff by equation 1.

$$K = -0.3819 + 0.8732\ (10.17)$$
$$K = 8.50 \text{ annual inches of runoff}$$

Gallons of runoff per acre were subsequently determined by:

$$G = Q = R \cdot A \cdot 27156$$
$$= 8.5 \quad 1 \quad 27156$$
$$= 230,236$$

Table 1. Number of overflows in mechanical discharge systems in a 41 year period (1926-67, excluding 1941) on Texas High Plains.

System size in rainfall equivalent inches	Discharge rate rainfall equivalent inches/24 hr.	Frequency of overflow
2	.2	75
	.4	59
	.6	50
3	.2	36
	.4	29
	.6	19
4	.2	17
	.4	11
	.6	8
5	.2	8
	.4	4
	.6	4
6	.2	4
	.4	4
	.6	3

Number of Overflows - Evaporative Discharge Systems

The cumulative amount of runoff retained in a collection basin in any time period is a function of the amount of rainfall, the rate of evaporation, the design depth of the system, and the number of overflows. This latter quantity, number of overflows, is a necessary element in determining the appropriate size of the optimum system. Consequently, given the expected precipitation rates, evaporation rates and design depth, the number of overflows may be estimated.

Evaporation from the collection basins of evaporative discharge systems was assumed to take place at the same rate as evaporation from playa lakes on the High Plains. Data on average evaporation rates in feet for each month are given in Table 2.

Table 2. Evaporation rates by months from playa lakes on the Texas High Plains.[1]

Month	Evaporation per month (feet)
January	.160
February	.233
March	.460
April	.617
May	.716
June	.845
July	.883
August	.801
September	.625
October	.493
November	.295
December	.202
	6.330

[1] Data on daily evaporation rates presented in "Hydrology, Conservation, and Management of Runoff Water in playa Lakes on the Southern High Plains," Conservation Report No. 8, (Agricultural Research Service, USDA) Washington, D. C., August, 1966, p. 12.

Evaporative discharge systems were assumed to have reached full capacity when the collection system was filled to a depth of eight feet. Preliminary estimates indicated that systems of less than eight feet in depth appeared to require an excessive quantity of land and systems greater than eight feet experienced a high rate of overflow. This latter phenomena was the result of the relationship between surface area and evaporation rates. That is, deeper systems with smaller surface areas had less evaporation, hence, large accumulations of runoff and more frequent overflows. The eight foot limitation was thus selected as a practical alternative to either deeper or more shallow systems. Expected precipitation rates were determined on the basis of the analysis of rainfall data for Lubbock, Texas. To determine the number of overflows from any given evaporative discharge system, evaporation rates expressed in feet in Table 2 must be converted to evaporation expressed in rainfall equivalent inches. This change in units of expression may be accomplished by the following equation:

$$X_i = \frac{SY_i}{8}, \quad i = 1, 2, \ldots, 12$$

X_i = evaporation expressed in inches of rainfall equivalent for the month i
Y_i = evaporation in feet for the month i
S = size of the collection basin in rainfall equivalent inches
8' = depth of water in the collection basin when filled to capacity

For example, the evaporation rate expressed in rainfall equivalent inches for the month of July for the 15" collection basin was calculated as follows:

$$X_7 = \frac{(.883)(15)}{8}$$

$$X_8 = 1.66$$

Therefore, a 15" system will experience a loss through evaporation of 1.66 inches of rainfall equivalent. To illustrate the example further, suppose that at the beginning of July, a 15" collection basin contained 5 inches of rainfall equivalent. Assume that during the month of July, two inches of rainfall equivalent inches contained in the collection basin at the beginning of August would be 5.34 " (5 + 2 - 1.66 = 5.34). The range of sizes for evaporative discharge systems considered in the study and the number of respective overflows for the 41 year period are given in Table 3.

Model Feedlot Assumptions

The relevant cost data were developed through use of a synthetic model analysis which gave tangible form to the various design criteria. The synthetic model analysis began with various assumptions such as feedlot size, cattle density, total feedlot area and slope. Next, a specific control and disposal system was selected, the necessary input-output relationships developed and subsequently costs were determined for each system. Three sizes of feedlots; 5,000 head, 10,000 head and 25,000 head were considered in the analysis.

Table 3. Number of overflows in evaporative discharge systems, in a 41 year period (1926-67, excluding 1941).

System size in rainfall equivalent inches	Number of overflows
12	111
13	83
14	58
15	16
16	7

Mechanical discharge systems were limited to discharging from any of five selected capacity collection basins to one of two alternative disposal areas: (a) an open field and (b) a playa lake. These disposal techniques are currently used by a number of feedlots on the High Plains. Technique (b), although a relatively efficient method of disposing of runoff water from a physical standpoint is rather inflexible since it depends on prior location of the feedlot in proximity to a playa lake of sufficient size to efficiently absorb the pollutant. Technique (a), open land disposal, appears to furnish the most readily utilizable alternative for any existing lot.

Specific assumptions relative to the physical environment of the model or representative feedlots are enumbered as follows:

1. Hydrological data used in the study is specific for the Lubbock County, Texas area. Similarly, the various cost coefficients such as labor rates, tax rates and construction and equipment costs are specific for the Lubbock County area.

2. The model feedlots are designed in the form of a square on land with an assumed average slope of 5 percent. The associated runoff control facilities are also constructed on land with a slope of 5 percent.

3. Land above the feedlot elevations utilized for parking, feed storage, administration, shipping, receiving or other agricultural use is assumed to be equivalent to 30 percent of the total area of the model feedlots. The total volume of runoff from this area will depend on total agreage, soil permeability, and vegetative cover. It was assumed that 50 percent of the precipitation falling on this area will become runoff and that this runoff water can be diverted around the feedlot.

4. Cattle density was stipulated at 150 square feet of pen space and 1.5 feed of bunk space per animal with a total of 200 animals per pen. Roads and alleys or service ways were assumed to be equivalent in area to 20 percent of the total pen space. Total acreage (pens, roads, and alleys) amounted to 20, 40, and 100 acres for the 5,000, 10,000 and 25,000 head model feedlots, respectively.

5. It was assumed that there was sufficient land below the feedlot to construct either the mechanical or evaporative system.

6. It was assumed that for disposal technique (a), the open land disposal modification, a sufficient acreage of open land adjacent to the model lots was available and could be used as a disposal facility. Table 4 indicates the assumed elevations and distances from the collection facility to the center of the open field for each model feedlots.

Disposal technique (b), the playa lake disposal modification, requires the availability of a lake of sufficient size for disposal of the total amount of runoff from each of the model feedlots. It was assumed that this lake was of sufficient size that the additional of runoff would not significantly alter the quality of the lake water for irrigation purposes. Distance to the lake was stipulated at 2,500 feet at zero difference in elevation from the collection point.

Table 4. Assumed difference in elevations and distances from the collection basin to the center of the open field disposal facility.

Lot size (head)	5,000	10,000	25,000
Elevation (ft.)	35	43	62
Distance (ft.)	700	860	1244

Investment Requirements

The size and, hence, costs of any specific system is determined by the size of the feedlot, the cumulative capacity of the collection basin and for the mechanical discharge systems, the rate at which runoff is pumped from the collection basin to the point of ultimate disposal. Physical components of mechanical discharge systems consisted of diversion terraces, the collection basin, pumps motors and auxilary piping. The open field disposal modification also included a disposal area component and sprinklers for final distribution. Some appreciation of the relative size and various physical characteristics of the mechanical dishcarge systems may be gained from Table 5. Evaporative discharge systems are conceptually quite simple and consisted solely of the collection basin and associated diversion terraces.

Total investment in mechanical discharge systems consisted of facility construction, land costs (including the open land disposal area) and mechanical equipment, Table 6. A comparison of the order of these costs for the open field and playa lake disposal modifications is summarized in Table 7. Total investment for the evaporative discharge systems is shown in Table 8.

A brief examination of the data in the above tables is in order. First, we should note that investment in water pollution control facilities is relatively modest for any system and any size of feedlot when compared with investment in other feedlot facilities and cattle. Accordingly, these data show that the largest mechanical discharge system (6"-.6") for a 25,000 head feedlot can be constructed for approximately $26,000, utilizing open field disposal and approximately $21,000, utilizing playa lake disposal, Table 6. Total investment for the largest evaporative discharge system for the same size feedlot amounted to $37,257, Table 8. Among the mechanical discharge systems considered, the open field modification required a smaller investment for the smaller feedlots at lower discharge rates. Conversely, as the system becomes larger and the discharge rate increases, the playa lake modification requires the smaller investment of the two modifications.

Referring again to Tables 6 and 9, we note that total investment for the evaporative discharge systems is considerably larger than that of the mechanical discharge counterparts. Total investment for the smallest capacity evaporative system for a 25,000 head feedlot amounts to $28,382, which is considerably in excess of investment requirements of the largest mechanical discharge system for the same size feedlot.

System Selection

Selection of the least cost runoff control system will depend on (1) the costs of constructing and operating the system and (2) the degree of protection desired. None of the systems considered in this report gave complete protection against overflow. A comparison of the amount of overflow protection provided by selected mechanical and evaporative discharge systems is shown in Table 10. These data indicate that a 5"-0.2" mechanical discharge system provide approximately the same amount of overflow protection as a 16" evaporative discharge system. Since the 16" evaporative system is the largest evaporative system considered in this analysis, a

Table 5. Collection basin capacity and time requirements for discharge, alternative system sizes, three model feedlots, Texas High Plains.

System Size in Rainfall Equivalent Inches		System Capacity			Required Pumping Time	Discharge Rate		
Basin Capacity	Discharge Rate/24 hrs	5,000 Head (20 acres)	10,000 Head (40 acres)	25,000 Head (100 acres)		5,000 Head (20 ac)	10,000 Head (40 ac)	25,000 Head (100 ac)
		(Gallons)	(Gallons)	(Gallons)	(Days)	(GPM)	(GPM)	(GPM)
2	.2	741,090	1,482,181	3,705,444	10	51	103	257
	.4				5	103	206	515
	.6				3	155	309	773
3	.2	1,215,341	2,430,682	6,076,704	15	56	113	281
	.4				8	113	225	563
	.6				5	169	338	844
4	.2	1,689,591	3,379,190	8,447,972	20	59	117	293
	.4				10	117	244	587
	.6				7	176	352	880
5	.2	2,165,450	4,327,691	10,819,232	25	60	120	301
	.4				13	120	240	601
	.6				8	181	361	902
6	.2	2,638,100	5,276,200	13,190,499	30	61	122	305
	.4				15	122	244	611
	.6				10	183	366	916

Table 6. Total investment costs, selected sizes and types of mechanical discharge systems, by system size, three model feedlots, Texas High Plains, 1968.

System Size in Rainfall Equivalent Inches		Open Field Disposal			Playa Lake Disposal		
Basin Capacity	Discharge Rate/24 hr	5000 Head	10,000 Head	25,000 Head	5000 Head	10,000 Head	25,000 Head
		Dollars					
2	.2	5235	6783	11950	6125	7379	11358
	.4	5491	7648	14183	6239	7879	11951
	.6	5936	8146	16533	6739	7962	12827
3	.2	5643	7691	14173	6546	8279	13518
	.4	5913	8571	16676	6647	8749	13966
	.6	6456	9147	19181	7147	8911	14938
4	.2	6052	8482	16193	6954	8963	15427
	.4	6399	9362	18702	7055	9497	15875
	.6	6864	10368	21750	7555	10001	16847
5	.2	6460	9346	18198	7363	9827	17432
	.4	6807	10226	20824	7464	10361	17880
	.6	7272	11234	23878	7964	10865	18852
6	.2	7308	10211	20201	8211	10692	19435
	.4	7655	11091	22905	8312	11226	19883
	.6	8198	12177	26004	8812	11730	20855

Table 7. Summary of the order of total investment cost of mechanical discharge systems on the Texas High Plains, 1968.

Feedlot size	Alternative systems (OF-open field, PL-playa lake)
5,000 head (all discharge rates)	OF < PL[1]
10,000 head (.2" and .4" discharge rate)	OF < PL
10,000 head (.6" discharge rate)	PL < OF
25,000 head (all discharge rates)	PL < OF

[1] The notation "<" is read OF less than PL.

Table 8. Total investment cost of evaporative discharge systems on the Texas High Plains, 1968.

System size in rainfall equivalent inches	Feedlot size (head)		
	5,000	10,000	25,000
	Dollars		
12	6,872	12,118	28,382
13	7,318	13,003	30,592
14	7,732	13,940	32,776
15	8,149	14,795	35,042
16	8,600	15,681	37,257

minimum of 7 expected overflows is the maximum protection afforded by evaporative systems. In contrast, the largest mechanical system 6"-0.6" has a minimum of 3 expected overflows for a 41 year period covered by the analysis, Table 2.

Given the expected number of overflows from any system, the prime consideration in selecting the appropriate system is one of annual operating costs. This cost data for all systems is summarized in Tables 11 and 12. As noted previously, a 5"-0.2" mechanical discharge system provides approximately the same degree of protection as a 16" evaporative discharge system. The mechanical discharge system can provide this protection at a cost of $2625 per year, utilizing playa lake disposal or alternatively $2930 per year, utilizing open field disposal. The 16" evaporative system in contrast experiences annual operating costs of $3487 for approximately the same amount of overflow protection for a 25,000 head feedlot.

Limitations

This study leaves a residue of unanswered questions. Most important are those questions which relate to the effect and extent of seepage from the collection basin and feedlot surfaces and the percolation of water under

Table 9. Summary of the order of total investment costs on mechanical and evaporative discharge systems compared with comparable overflow rates on the Texas High Plains, 1968.

Feedlot size	Alternative systems (OF-open field, PL-playa lake, E-evaporative)
5, 000 head	OF<PL<E
10, 000 head	OF<PL<E
25, 000 head	PL<OF<E

Table 10. Mechanical and evaporative discharge systems compared by approximate number of overflows, by system size, on the Texas High Plains.

Mechanical			Evaporative	
System size in rainfall equivalent inches				
Basin capacity	Discharge rate/24 hrs	Estimated frequency of overflow (41 year period)	System size in rainfall equivalent inches	Estimated frequency of overflow (41 year period)
2	.2	75	13	83
2	.4	59	14	57
4	.2	17	15	16
5	.2	8	16	7

the disposal area and feedlot. These questions are particularly important with respect to their potential as a source of pollution of under ground water supplies.

Estimates made in this study as to the percent of runoff that may be expected from a given level of precipitation were based on Kansas data and hence, may be biased due to the influence of environmental factors. Although the experiments in Kansas were extensive and were conducted under a variety of conditions, climatic and environmental factors may be sufficiently different from those experienced elsewhere to alter the size of the least cost system. Experiments should be conducted at other locations to determine the reliability of the data in terms of local conditions.

Calculations as to the amount of land required for the open field disposal modification were based on the water absorption capacity of the soil. The ability of High Plains soils to absorb large quantities of pollutant without adverse effects such as pollution of the underground water supply, nitrite ion accumulation, phosphorous ion accumulation or other effects is unknown. A 50 percent safety factor was provided in determining land

Table 11. Annual costs, mechanical, discharge systems, open field and playa lake disposal modifications, by system size, three model feedlots, Texas High Plains, 1968.

System Size in Rainfall Equivalent Inches: Basin Capacity	Rate/24 hrs.	Open Field: 5000 Head	Open Field: 10,000 Head	Open Field: 25,000 Head	Playa Lake: 5000 Head	Playa Lake: 10,000 Head	Playa Lake: 25,000 Head
		dollars					
2	.2	776	1157	2429	942	1234	2101
	.4	804	1327	2796	970	1326	2234
	.6	868	1436	3298	1065	1355	2496
3	.2	809	1288	2587	981	1305	2298
	.4	840	1409	3106	1004	1397	2421
	.6	919	1522	3681	1099	1456	2671
4	.2	844	1357	2761	1015	1368	2458
	.4	879	1477	3279	1037	1475	2580
	.6	953	1675	4901	1133	1580	2830
5	.2	878	1428	2930	1049	1438	2625
	.4	913	1547	3460	1070	1545	2747
	.6	987	1745	4273	1167	1650	2997
6	.2	952	1498	3098	1126	1508	2792
	.4	986	1617	3633	1145	1615	2914
	.6	1065	1820	4456	1241	1720	3165

requirements for the open field disposal modification. Other studies have suggested land requirements for disposal equal in area from one quarter to one half of the area of the feedlot. In neither case are the parameters of the problem sufficiently well known to specify these land requirements with any real degree of accuracy.

Conclusions

We should emphasize that in general this study is specific for the southern High Plains, particularly so with reference to the rainfall frequencies used for determining the size of the necessary collection basin. Other areas, with different rainfall frequencies will experience different overflow frequencies and will require either larger or smaller collection basins. The main points of emphasis are, first that the computational procedure used here can be adapted for any area. Secondly, it would appear that the cost of controlling runoff from cattle feedlots in any area is economically feasible. Finally, systems which utilize mechanical evacuation of the collection basins appear more promising than those which depend on natural evaporation.

Table 12. Annual costs, evaporative discharge systems, by system size, three model feedlots, Texas High Plains, 1968.

System size in rainfall equivalent inches	Size 5,000 head	10,000 head	25,000 head
Basin capacity	Dollars		
12	653	1178	2793
13	688	1248	2966
14	720	1320	3137
15	752	1386	3313
16	788	1441	3487

METHODS OF GRAIN PROCESSING AND THE EFFECTS ON FEED EFFICIENCY AND RATE OF GAIN

by

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Grain is commonly processed for feedlot cattle in modern finishing operations, in contrast to common practice in the past, because hogs no longer follow cattle to utilize undigested grain, all ration ingredients are combined together in a completely mixed ration (in which case the use of whole grain is less acceptable for the formation of a stable homogenous mixture), the need for maximum efficiency is greater today because there is less margin for profit, and modern record keeping systems used by cattle feeders today allow them to accurately identify even small differences in efficiency.

The cattle feeder must choose the method of processing he feels is best suited (most profitable) for his operation. A number of factors influence the choice of processing method. Several are:

A. Nutritional factors which affect cattle performance and merit
1. Feed efficiency
2. Rate of gain
3. Feed intake
4. Cattle health
5. Carcass merit

B. Non-nutritional factors
1. Type of feedlot (custom vs. owned cattle)
2. Size of feedlot
3. Type of ration fed
4. Costs - installation and conversion
5. Costs - operation and maintenance
6. Engineering considerations
7. Storage facilities and costs
8. Handling and storage characteristics
9. Labor requirements

Certainly two of the very important considerations regarding the influence of the processing method are rate and efficiency of gain. An estimate of the relative importance of rate of gain and feed efficiency is shown in Table 1.

Small percentage improvements in feed efficiency are magnified to large sums in sizeable feeding operations. For instance, assume a total feed requirement of 3000 lb. per steer and a $2.00/cwt. feed cost. Improvements in efficiency of 1, 5, and 10 percent mean savings of 30, 150, and 300 lb. of feed worth $.60, $3.00, and $6.00, respectively. A 10,000 head feedlot feeding 25,000 head per year would realize a saving of $15,000 or $75,000 or $150,000. In some cases improvements in feed conversion as high as 10 to 20 percent can be attained. It is obvious why cattle feeders are constantly on the lookout for better methods of processing.

Table 1. An example of the relative importance of improvement in rate of gain and feed efficiency.

	Normal	10% Improvement	Saving
	lb.	lb.	
Rate of gain	3.00	.30	10% of \$.05 (yardage) = .005
			10% of \$.04 (interest) = .004
Feed/lb. gain	7.00	.70	.7 x \$.02 (cost/lb.) =\$ .014

Several conventional methods of processing have been used for many years, while several "modern" methods are now available. They may be described as follows:

Conventional Methods

1. Grinding, usually done with a hammer mill, with the particle size of the ground product determined by the size of holes in the screen.
2. Dry rolling, also called cracking or crushing, with particle size influenced by roller pressure and spacing between the rollers.
3. Steam rolling, or crimping, also called conventional steam rolling. It invelves short time exposure to steam, for the primary purpose of softening the kernel for rolling.
4. Pelleting, usually preceded by grinding or rolling.

Modern Methods

1. Steam flaking, which involves much greater exposure to steam, and the production of a much thinner flake, than conventional steam rolling.
   a. Steaming may be at atmospheric pressure for a considerable time, such as 20 minutes or more.
   b. Steaming may be done under pressure for a short time, such as 1 minute at 50 psi.
2. High moisture processing,
   a. High moisture harvesting, such as at moisture levels of 20 to 40 percent.
   b. Reconstituting (the addition of water to dry grain) to raise the moisture to a high level, such as 20 to 40 percent.

In either type of high moisture processing, storage under essentially oxygen-free conditions is necessary, and some form of processing (grinding, rolling) is necessary either before or after storage for efficient utilization of the grain.

Other methods of processing, such as popping and extruding, are currently being investigated. Additional methods will undoubtedly be added added to the list in the future.

Milo

Conventional Methods

Various comparisons of conventional methods of processing milo are summarized in Table 2, involving a total of 28 trial comparisons. The number of trials upon which each comparison is based gives some basis for confidence which can be placed in the average results. The following conclusions can be made from the summary:

1. Grinding vs. dry rolling. There is little difference between them in terms of cattle performance. Decisions would probably be made on the basis of other factors, such as dustiness, fines, cost of equipment, and maintenance and operation costs.
2. Fineness of grind. Fine grinding clearly has an advantage over coarse grinding, based on 10 experiments.

There has been some confusion about the influence of particle size. In some experiments a fine textured grain produced by grinding has been compared to a coarse textured grain produced by rolling, with little difference between the two methods (Table 2). It was often concluded that particle size was of no importance. Apparently, rolling grain imparts a beneficial property to grain which compensates for a large particle size. Fine particle size in rolled grain seems to be of little value. The particles resulting from rolling may be multi-fractured and therefore more susceptible to the entry of enzyme-containing fluid for digestion than large particles resulting from grinding.

Table 2. Conventional methods of processing milo.

Processing Method			Percent of control method[1]		
No. of Trials	Method of interest	Control method	Daily gain	Daily[2] feed	Feed/lb.[2] gain
			%	%	%
5	Fine grinding	Dry rolling	99	98	99
10	Fine grinding	Coarse grinding	101	94	95
3	Fine rolling	Coarse rolling	96	97	100
4	Steam rolling	Dry rolling	98	100	102
8	Pelleting	Grinding	104	94	91
4	Pelleting	Rolling	105	92	93

[1] The processing method listed in the method of interest column is expressed as a percent of the control method. For example, the daily gain on finely ground milo has been 99 percent the daily gain on dry rolled milo.

[2] All feed intake and feed efficiency data were converted to 90 percent dry matter basis.

If milo is rolled, all of the kernels should be broken. This is illustrated by the data obtained in a recent feeding trial, shown in Table 3. The rolled grain in this instance contained about 25 percent whole grain and obviously was not utilized as efficiently as ground grain. This data also further illustrates the value of small particle size if the grain is ground. The very fine grain was ground through a $\frac{1}{16}$ inch screen and was very flour-like in texture; the finely ground product was ground through a $\frac{1}{8}$ inch screen.

3. Steam rolling. Conventional steam rolling has no advantage over dry rolling. A summary of 4 trials (Table 2) shows steam rolling resulted in a slight decrease in both rate of gain (2 percent) and feed efficiency (2 percent). These results suggest that additional expense for equipment for conventional steam rolling is not justified, compared to dry rolling.

4. Pelleting. Pelleting ground milo improved rate of gain 4 percent and feed efficiency 9 percent compared to unpelleted ground milo, and pelleting rolled milo improved rate of gain 5 percent and feed efficiency 7 percent compared to unpelleted rolled milo (Table 2). These results, based on 12 trials, are rather striking and suggest much potential for pelleting, in spite of considerable processing cost. However, pelleting has rather consistently resulted in a 1 percent decrease in dressing percentage and a slight lowering of carcass grade which tends to eliminate much of the advantage in feed efficiency. Perhaps further research effort in the area of pelleting is needed.

Modern Methods

1. Steam flaking. A summary of 11 experiments comparing steam flaked milo to dry rolled or ground milo shows an advantage for steam flaked milo of 7 to 10 percent in rate of gain and 3 to 7 percent in feed efficiency (Table 4). Contrary to most processing methods which improve feed efficiency, steam flaking also increases feed intake, which in turn increases rate of gain. The summary shown in Table 4 includes both steam-pressure processing and steaming at atmospheric pressure. The importance of a flat flake has been demonstrated at the Arizona Station, and may help explain the lack of consistent results from steam flaking at various stations. There may also be a difference in the natural availability of starch among milo grains, and therefore a difference in benefits obtained from steam flaking. Improvements in feed efficiency as high as 13 percent have been observed in Oklahoma experiments, indicating the large potential improvement in feed conversion from steam processing in addition to the consistently sizeable increase in rate of gain.

Table 3. Coarse rolling vs. fine grinding vs. very fine grinding of milo (Oklahoma).

Processing method	Daily gain	Daily feed	Feed/lb. gain
	lb.	lb.	lb.
Coarse rolling	2.28	16.9	7.42
Fine grinding	2.39	16.8	7.04
Very fine grinding	2.24	14.7	6.55

Table 4. Steam flaking vs. grinding or rolling of milo.

No. of trials	Processing method: Method of interest	Control method	Percent of control method[1]: Daily gain	Daily[2] feed	Feed/lb[2] gain
			%	%	%
6	Steam flaking	Grinding	110	102	93
5	Steam flaking	Dry rolling	107	103	97

[1] The processing method listed in the method of interest column is expressed as a percent of the control method.
[2] All feed intake and feed efficiency data were converted to 90 percent dry matter basis.

2. High moisture processing. In 10 comparisons, high moisture harvesting improved feed efficiency an average of 10 percent and had no affect on rate of gain compared to dry processing of milo (Table 5). A summary of 3 experiments shows that reconstituting resulted in a 9 percent improvement in feed efficiency and a 3 percent improvement in rate of gain, compared to dry milo (Table 4). Recent Oklahoma research (Tables 6 and 7) shows even greater promise for high moisture processing.

Note improvements in feed efficiency of up to 16.8 percent for reconstituted milo and 18.3 and 19.0 percent for high moisture harvested milo, compared to dry ground milo.

The results in Table 6 indicate that rolling of high moisture milo is preferable to grinding, in terms of both rate of gain and feed efficiency, especially in the reconstituted milo. This again suggests the beneficial influence of the rolling process. Feed efficiency was excellent with the

Table 5. High moisture processing vs. dry processing of milo.

No. of trials	Processing Method: Method of interest	Control method	Percent of control method[1]: Daily gain	Daily[2] feed	Feed/lb.[2] gain
			%	%	%
10	High moisture harvesting	Dry	100	90	90
3	Reconstituting	Dry	103	93	91

[1] The processing method listed in the method of interest column is expressed as a percent of the control method.
[2] All feed intake and feed efficiency data were converted to 90 percent dry matter basis.

Table 6. High moisture methods of processing milo, compared to finely ground dry milo (Oklahoma).

Processing method	Wt. /bu.[1]	Dry matter	Daily gain	Daily[1] feed	Feed/lb. gain	Efficiency improvement over fine ground
	lb.	%	lb.	lb.	lb.	%
Finely ground, dry	38.8	85.5	2.39	16.8	7.04	
Recon.[2] ground[4]	31.0	74.3	2.33	15.0	6.44	8.5
Recon. rolled[4]	24.5	73.4	2.68	15.7	5.86	16.8
HMH[3] ground	24.4	70.1	2.24	13.4	6.00	14.8
HMH rolled	21.3	68.9	2.63	15.1	5.75	18.3

[1] On a 90 percent dry matter basis.
[2] Reconstituted after dry harvesting, then stored in oxygen-free structure.
[3] High moisture harvested, then stored in oxygen-free structure.
[4] Ground or rolled immediately before feeding.

Table 7. High moisture harvested milo, compared to dry milo(Oklahoma).

Processing method	Wt. /bu.[1]	Dry matter	Daily gain	Daily[1] feed	Feed/lb. gain	Efficiency improvement over dry milo
	lb.	%	lb.	lb.	lb.	%
Dry milo, ground	47.2	87.7	2.9	25.8	9.05	
HMH milo,[2] ground	31.1	73.8	3.2	23.3	7.33	19.0

[1] On a 90 percent dry matter basis.
[2] High moisture harvested, ground, then stored in a concrete trench silo until fed.

high moisture harvested milo, regardless of whether it was stored in the ground form in a trench silo (Table 7) or stored whole in an oxygen-free structure and either ground or rolled before feeding (Table 6). Perhpas the reconstituting process does not return the milo carbohydrates to a form as readily available as in the high moisture grain, and consequently the carbohydrates in the reconstituted grain are benefitted more by rolling.

On the basis of results shown in Table 8, it appears that reconstituted milo must be stored in the whole form to obtain increased utilization.

Perhaps the changes which occur during the reconstitution process are similar if not identical to those of germination, and the integrity of the whole kernel is necessary for the enzymatic changes which convert starch to more available carbohydrates.

Since it is rather difficult to increase the moisture level of reconstituted milo above 20-22 percent, an important question relates to the optimum moisture level of reconstituted milo. Moisture levels of 22, 30, and 38 percent were compared in a recent trial (Table 9). On the basis of feed efficiency, 30 percent moisture has an advantage over 22 percent, but there is no additional advantage in attaining a moisture level of 38 percent.

Another important consideration is the necessary time of storage following reconstitution for improved utilization. Work at the Texas Experiment Station indicated no difference between 10 and 20 days of storage time. A feeding trial comparing storage times of 5, 10, and 20 days is currently in progress at the Oklahoma Station.

Corn

Eight comparisons involving various methods of processing corn, based on 32 different trial comparisons, are summarized in Table 10. The following conclusions are made on the basis of these summaries.

1. Grinding is superior to dry rolling in terms of both rate of gain and feed efficiency.
2. Pelleting, just as with milo, results in a sizeable improvement in feed efficiency (10-11 percent) and a 1-5 percent improvement in rate of gain, compared to rolling and grinding.
3. Steam flaking results in a marked increase in feed efficiency (8 percent) compared to grinding or rolling. In rate of gain, steam flaking appears to be superior to rolling but inferior to grinding.
4. High moisture processing methods have been advantageous over dry methods. Reconstituting of shelled corn has resulted in small improvements in efficiency and rate of gain, but the improvement in efficiency has been much smaller than with milo, probably because the starch in milo is less readily available and therefore more susceptible to improvement from processing.

High moisture harvesting of shelled corn has resulted in some improvement in efficiency (5 percent) and a large increase in daily gain (11 percent). The improvement in efficiency in ear corn is even greater (8 percent). A comprehensive comparison of both dry and high moisture harvested shelled corn and ear corn is in progress at the Oklahoma Station (at Panhandle State College).

Table 8. Feedlot performance of calves as affected by physical form of milo when reconstituted (Oklahoma).

Form and Process	Wt./bu.[1]	Dry matter	Daily gain	Daily[1] feed	Feed/lb.[1] gain	Efficiency improvement over dry milo
	lb.	%	lb.	lb.	lb.	%
Dry, ground	42.7	87.4	2.34	14.7	6.29	
Whole[2]	26.4	71.8	2.56	14.6	5.70	9.4
Ground[3]	34.8	67.6	2.28	14.9	6.51	-4.8

[1] The processing method listed in the method of interest column is expressed as a percent of the control method.
[2] All feed intake and feed efficiency data were converted to 90 percent dry matter basis.
[3] High moisture harvested.

Table 9. Effect of percent moisture on utilization of reconstituted milo (Oklahoma).

	Percent moisture			
	14 (Dry)	22	30	38
Daily gain, lb.	2.53	2.74	2.48	2.45
Feed intake, lb.	16.9	17.6	14.4	14.20
Feed/lb. gain, lb.	6.69	6.42	5.82	5.80
Efficiency improvement over dry milo, percent		4.0	13.0	13.30

Barley

The starch of barley is apparently more readily available to cattle than is true of some of the other feed grains, as attested by the usual good feed efficiency obtained with barley. Therefore, differences in performance due to processing are often relatively small. Several methods of processing are compared in Table 11.

Steam rolling or steam flaking may be methods of choice over grinding or dry rolling, primarily in terms of maximum rate of gain, but it should be recognized that improvements in feed efficiency will be relatively small. High moisture methods likewise may be methods of choice due to considerations such as procurement cost at a high moisture stage and economy of storage in trench silos, but again it appears that large increases in feed efficiency should not be expected.

Table 10. Comparisons of methods of processing corn.

	Processing method		Percent of control method[1]		
No. of trials	Method of interest	Control method	Daily gain	Daily[2] feed	Feed/lb.[2] gain
2	Grinding	Rolling	106	99	95
3	Pelleting	Grinding	105	94	89
2	Pelleting	Rolling	101	87	90
4	Steam flaking	Grinding	95	90	92
6	Steam flaking	Rolling	106	98	92
6	Shelled-reconstituting	Dry	102	102	97
3	Shelled-HMH[3]	Dry	111	107	95
7	Ear corn-HMH[3]	Dry	104	94	92

[1] The processing method listed in the method of interest column is expressed as a percent of the control method.

[2] All feed intake and feed efficiency data were converted to 90 percent dry matter basis.

[3] High moisture harvested.

Table 11. Comparisons of methods of processing barley.

	Processing method		Percent of control method[1]		
No. of trials	Method of interest	Control method	Daily gain	Daily[2] feed	Feed/lb.[2] gain
3	Steam rolling	Rolling	103	101	98
5	Steam flaking	Grinding	100	95	95
5	Steam flaking	Rolling	104	103	100
1	HMH[3]	Dry	111	107	96

[1] The processing method listed in the method of interest column is expressed as a percent of the control method.

[2] All feed intake and feed efficiency data were converted to 90 percent dry matter basis.

[3] High moisture harvested.

Wheat

Since wheat has not been a widely used feed grain over the years, less research on rpocessing has been done than on other feed grains. Wheat is definitely competitive as an energy source in many operations today, and some comparisons of methods of processing are presented in Table 12.

Table 12. Comparisons of methods of processing wheat.

	Processing method		Percent of control method[1]		
No. of trials	Method of interest	Control method	Daily gain	Daily[2] feed	Feed/lb.[2] gain
8	Steam rolling	Rolling	99	99	100
2	Pelleting	Rolling	100	98	99

[1] The processing method listed in the method of interest column is expressed as a percent of the control method.
[2] All feed intake and feed efficiency data were converted to 90 percent dry matter basis.

It appears that there is little difference among the processing methods which have been compared. Research involving steam flaking and high moisture processing methods has not been reported.

Other Processing Methods

Popping of milo is a method which shows considerable promise. In work at the Texas Station, popping milo increased its degestibility markedly and improved feed efficiency up to 16 percent. Feed intake was reduced sufficiently to cause a reduction in gain, but possibly a modification of the technique by additional research will result in another useful processing method.

Addititional processing methods are in the experimental stage; others will surely be developed in the future.

NUTRITION AND CARCASS COMPOSITION[1]

by

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An animal having access to an adequate feed supply deposits protein, fat and minerals at different rates depending upon the stage of the growth cycle. It is possible, therefore, to alter the composition of the body by changing the level of feeding during the different stages of growth. A low plane of nutrition during early growth followed by a high plane results in carcasses having a low muscle content and a high percentage of fat. This is brought about because muscle is an early growing tissue and restriction during early growth will retard muscle development. Fat, on the other hand, is deposited most abundantly later in the growth period and a high level of feeding during late growth stimulates fat deposition. The reverse; a high plane during early growth followed by a restricted level produces leaner carcasses. In order to produce these results, however, the degree of restriction has to be severe.

Little is known of the effects of nutrients other than energy upon carcass composition. A restriction of almost any nutrient will normally result in a reduced appetite so that there is an energy deficiency as well as a deficiency of the primary nutrient causing the reduced appetite. In certain laboratory animals a protein intake well above that normally considered necessary has brought about an increased protein deposition. Some unpublished information accumulated by the author at the University of California showed a similar trend with cattle in that protein intakes well above the listed requirements stimulated nitrogen retention during short term balance studies. An experiment recently completed at the Imperial Valley Field Station showed that a ration containing approximately 25 percent protein promoted gains containing approximately the same amount of protein but 23 percent less fat than a ration containing 10 percent protein. Since protein feeds are expensive, it appears doubtful that altering the protein content of the ration will be an economical means of producing leaner carcasses.

Adding fat up to a level of 10 percent in the ration of beef cattle has shown no effect on carcass composition. The kind of fat in the ration of cattle has a slight effect upon the kind of fat deposited in the body.

Butterfield in Australia has postulated that severe energy restriction in a very young animal will result in a greater restriction of muscle than of viscera since the viscera has first priority on the available nutrients. Upon a return to an adequate energy intake the small muscle mass would be incapable of absorbing the metabolized nutrients, the surplus of which would be deposited as fat. On the other hand, an older animal subjected to severe restriction would suffer a less disproportionate loss and upon returning to adequate energy the metabolized nutrients could be deposited in muscle tissue so that less would be deposited as fat since fat would not

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[1] Paper to be presented at the Oklahoma Cattle Feeders Seminar, February 7, 1969.

be extensively until the muscle had been repleted. According to this postulation, therefore, restriction and refeeding in a very young animal will result in a carcass low in protein and high in fat while in an older animal fat will not be deposited until the muscle has recovered its normal weight. Certain work with lambs and rats support this theory. It has not been adequately tested with beef cattle to determine if some practical use can be made of it.

In the feedlot one does not normally wish to subject cattle to severe energy restriction in order to alter body composition. It was of interest to us, therefore, to determine if altering the energy level in the ration but with free choice feeding would affect the deposition of fat and protein.

One of the first indications we had that energy intake could affect carcass characteristics was the response of cattle to an energy supplement in addition to free choice alfalfa. The results are shown in Table 1. The important point illustrated by these data is that although the daily gains were not significantly stimulated by continuous supplementation the yield and carcass grade were significantly increased. This finding suggested that continuous supplementation stimulated fattening without stimulating daily gains. Table 2 shows the results of an experiment designed to determine the level of energy supplement necessary to bring about this effect. Since maximum stimulation of fain occurred at a lower level of supplementation than the maximum yield and grade, it appears that the level of energy supplementation may be important in affecting carcass composition without affecting weight gains.

In further studies weaned Hereford steer calves weighing approximately 450 pounds and yearling Hereford steers averaging 620 pounds were fed 20 and 90 percent concentrate rations for 264 days with representative animals being slaughtered from each group after 89, 180 and 264 days on feed. Carcass composition was determined by the specific gravity method and measurements were made of carcass grade, marbling score, rib eye area, and thickness of external fat cover over the rib. The results after 264 days on feed are presented in Table 3. With both calves and yearlings

Table 1. Response of steers fed alfalfa soilage with various supplements.

	Supplemental treatment		
Item	None	Concentrate after 84 days	Concentrate for entire period
Initial weight, lb.	668	668	660
Final weight, lb.	969	1035	1034
Daily gain, lb.	1.80	2.17	2.23
Total feed consumption:			
Roughage (90%DM), lb.	2990	2570	2016
Concentrate (as fed), lb.	0	638	1109
Dressing percent	56.7	58.9	60.8
Grade, percent:			
Choice	8	18	64
Good	75	82	36
Standard	17	0	0

Table 2. Response to various levels of continuous supplementation.

Item	Concentrate, % of full food				
	0	25	50	75	100
Initial weight	541	545	543	542	543
Daily gain	2.01	2.17	2.28	2.34	2.35
Daily feed consumption:					
Roughage (90%DM), lb.	18.3	17.1	14.6	14.0	12.5
Concentrate (as fed), lb.	0	1.8	3.5	5.1	6.2
Dressing percent	58.5	57.7	58.3	59.7	59.8
Grade, percent:					
Choice	0	0	12	50	38
Good	88	100	88	50	62
Standard	12	0	0	0	0

Table 3. Effect of ration on carcasses of calves and yearlings fed 264 days.

Item	Calves		Yearlings	
	High roughage	High concentrate	High roughage	High concentrate
Dressing	57.4	60.6	59.5	62.4
Carcass grade score[1]	6.5	9.0	7.7	9.1
Carcass composition				
Fat, %	19.1	24.8	23.5	26.6
Protein, %	17.5	16.3	16.6	15.9
Carcass weight, lb.	534	600	634	698
Fat, lb.	102	149	149	186
Protein, lb.	93	98	105	111
Marbling score[2]	4.1	5.5	5.1	6.6
Rib eye area, sq. in.	10.9	11.7	11.6	12.7
Fat cover, in.	0.40	0.57	0.72	0.84

[1] Carcass grade score:
5 - low good
6 - good
7 - high good
8 - low
9 - choice
10 - high choice

[2] Marbling score:
3 - trace
4 - slight
5 - small
6 - modest
7 - moderate
8 - sl. abundant

the high concentrate ration resulted in a carcass containing a high percent of fat, a slightly lower percent of protein and which graded higher, had greater marbling, a larger rib eye, and slightly more external fat over the rib. In the case of the calves the high concentrate treatment resulted in 66 lb. more dressed carcass of which 47 lb. was fat and only 5 lb. was protein. The remaining 14 lb. was water and ash. With the yearlings the corresponding increases were 64 lb. of carcass, 37 lb. of fat, 6 lb. of protein, and 21 lb. of water and ash.

Table 4 shows the effect of the dietary treatments after a constant weight gain of 400 pounds. With calves the high roughage ration required 30 days more to put on a gain of 400 pounds and the carcasses graded lower, contained less fat and less marbling than those produced on a high concentrate ration. With yearlings, however, if animals were slaughtered at a uniform gain of 400 pounds the high roughage cattle required 83 days more to produce this gain, but the carcasses were equal to those fed the high concentrate in carcass grade, fat percent, marbling and rib eye area. It appears, therefore, that if calves are fed to a uniform weight, a high concentrate ration will produce higher grading and fatter carcasses with more marbling than will a high roughage ration. If yearling cattle, however, are to be fed for a given amount of total gain, a high concentrate ration will produce this gain in considerably less time but the carcasses will be of no better than those produced from a high roughage ration. This tends to fall in line with the postulation of Butterfield relative to the effects of high energy feeding and fat gains in cattle of different ages.

The above data suggest that possibility that with older cattle a finishing period on a low energy ration may produce as desirable carcasses as a higher energy ration. A study was, therefore, set up to determine the effects of altering energy levels during the feeding period. One hundred and eight Herford calves were divided into six groups and assigned to the treatments shown in Table 5. Representative animals were slaughtered at each change in the ration for study of changes in body composition. The results are presented in Tables 6 through 9. Table 6 shows that the cattle gaining the most total weight were those fed for the entire period on the

Table 4. Effect of ration on carcasses of calves and yearlings after a 400 pound gain.

Item	Calves		Yearlings	
	High roughage	High concentrate	High roughage	High concentrate
Days fed	253	223	243	160
Dressing percent	57.1	60.0	59.0	61.6
Carcass grade score	6.2	7.9	7.6	7.7
Carcass composition				
Fat, %	18.8	22.9	23.3	23.8
Protein, %	17.5	16.7	16.6	16.5
Carcass weight, lb.	520	550	620	635
Fat, lb.	98	126	144	151
Protein, lb.	91	92	103	105
Marbling score	3.9	4.9	5.2	5.3
Rib eye area, sq. in.	10.7	10.9	11.2	11.1
Fat cover, in.	0.38	0.47	0.65	0.71

Table 5. Design of experiment.

Treatment designation	Description of treatment
LLL	Low energy ration (20% concentrate) for 273 days.
LLH	Low energy for 182 days and high energy (90% concentrate) for 91 days.
LMH	Low energy for 91 days, medium energy (55% concentrate) for 91 days and high energy for 91 days.
HML	High energy for 91 days, medium energy for 91 days, and low energy for 91 days.
HHL	High energy for 182 days and low energy for 91 days.
HHH	High energy for 273 days.

Table 6. Daily weight gains by period.

Treatment	Initial wt.	Period 1 gain	Period 2 gain	Period 3 gain	Overall gain	Final wt.
	lb.	lb.	lb.	lb.	lb.	lb.
LLL	403	1.42	1.64	1.63	1.56	829
LLH	404	1.46	1.60	2.52	1.86	911
LMH	437	1.54	1.68	2.50	1.90	957
HML	408	2.12	1.94	1.39	1.81	903
HHL	398	2.34	2.13	1.12	1.86	907
HHH	410	2.17	2.39	1.86	2.14	993

high energy ration with the LMH, HHL, LLH, HML and LLL following in that order, the differences among the LMH, HHL, LLH and HML being small and not significant. A very important consideration is the amount of feed required per pound of gain. Table 7 shows the amounts of concentrates and roughage required to produce a pound of gain on the various treatments. With the cost of concentrates and roughages in the finished ration one can determine the least cost combination. One must also consider, however, the value of the finished product. The composition of the gain is shown in Table 8 and some carcass characteristics are listed in Table 9. In general, the fat content of the gain is directly related to the amount of concentrate feed. Since, however, the distribution of fat is very important, the fat cover, marbling scores, and carcass grade scores shown in Table 9 are of interest. Although no conclusions can be drawn at this point, it is interesting that the LLH treatment produced a choice carcass with modest marbling and 21.7 percent body fat while the HHH combination produced a choice carcass with modest marbling but with 25.3 percent body fat. Further study is necessary to find these combinations which will produce high grading carcasses with adequate marbling but with low fat content.

Tables 10 through 14 show the results of a comparable study with yearling cattle. Table 10 shows the cattle fed the high energy level throughout had the highest overall gain and, as expected, those fed the

Table 7. Feed per pound of gain.

Treatment	Concentrates	Roughage	Concentrate per pound of gain	Roughage per pound of gain	Total feed per pound of gain
	lb.	lb.	lb.	lb.	lb.
LLL	881	3522	2.07	8.27	10.34
LLH	1915	2380	3.78	4.69	8.47
LMH	2411	1856	4.64	3.57	8.21
HML	2154	1978	4.35	4.00	8.35
HHL	2554	1405	5.02	2.76	7.78
HHH	3571	397	6.13	0.68	6.81

Table 8. Composition of gain.

Treatment	Total weight gained	Total fat gained	Total protein gained	Composition of gain	
				fat	protein
	lb.	lb.	lb.	%	%
LLL	426	111	78	26.1	18.3
LLH	507	158	89	31.2	17.6
LMH	520	173	90	33.3	17.3
HML	495	146	89	29.5	18.0
HHL	509	160	89	31.4	17.5
HHH	583	210	96	36.0	16.5

Table 9. Carcass characteristics.

Treatment	Rib eye area	Fat cover	Marbling score[1]	Carcass grade score[2]	Final body fat	Yield
	sq. in.	in.			%	%
LLL	10.8	0.51	5.0	6.9	18.2	58.6
LLH	11.8	0.55	6.2	9.1	21.7	61.8
LMH	12.1	0.63	6.6	8.7	22.5	61.8
HML	11.8	0.71	6.0	8.8	20.5	61.1
HHL	11.6	0.64	6.3	9.0	21.9	61.5
HHH	11.6	0.73	6.3	9.0	25.3	61.8

[1] and [2] See marbling and carcass grade score key following Table 3.

Table 10. Empty weight gains by period.

Treatment	Initial empty weight	Daily gain during period no. 1	2	3	Means	Final empty weight
	lb.	lb.	lb.	lb.	lb.	lb.
LLL	637	1.87	0.81	1.70	1.46	1036
LLH	621	1.87	0.81	2.72	1.80	1113
LMH	651	1.87	1.87	2.56	2.10	1223
HML	667	2.68	1.56	1.16	1.80	1159
HHL	655	2.68	1.34	1.29	1.77	1137
HHH	644	2.68	1.34	2.73	2.25	1258

low energy gained at the slowest rate. Tables 11, 12, and 13 show the feed intake, efficiency, composition of the gain and the carcass characteristics for the entire 273 day feeding period. It is obvious that as the energy concentration in the ration increased there was a corresponding increase in the total fat deposited and the gain contained more fat. Since, however, the high energy rations promoted faster gains, the cattle would reach a given weight earlier than those on a low energy ration and this could be the reason for the higher fat content of the gain on high energy rations. Table 14 shows the carcass characteristics at the time each lot gained 400 pounds and thus would be comparable in size as shown by the carcass weights. The time required to reach this weight, obviously, would vary. Even at the same total gain those cattle consuming the three higher energy rations had a higher fat content in their carcasses with slightly less protein. It is apparent, therefore, that high energy rations stimulate fat deposition even when cattle are fed for the same total gain or are slaughtered at the same weight.

Another comparison is important in considering this problem. Since high energy rations stimulate fat deposition and a faster rate of gain, it seemed important to compare rations at the same carcass grade. Table 15 presents such a comparison. It is obvious that if animals are taken to the same grade, there are little differences in the carcasses from cattle

Table 11. Feed consumption and efficiency.

Treatment	Daily feed: Concentrates	Daily feed: Roughage	Total	Daily empty weight gain	Feed per pound of gain: Concentrates	Feed per pound of gain: Roughage	Total
	lb.	lb.	lb.	lb.	lb.	lb.	lb.
LLL	4.9	19.4	24.3	1.46	3.4	13.3	16.7
LLH	10.2	13.8	24.0	1.80	5.7	7.7	13.4
LMH	13.2	11.1	24.3	2.10	6.3	5.3	11.6
HML	12.6	10.3	22.9	1.80	7.0	5.7	12.7
HHL	14.5	6.9	21.4	1.77	8.2	3.9	12.1
HHH	19.7	2.2	21.9	2.25	8.8	1.0	9.8

Table 12. Composition of gain.

Treatment	Empty weight gained	Total fat gained	Total protein gained	Composition of gain fat	Composition of gain protein
	lb.	lb.	lb.	%	%
LLL	399	168	65	42.1	16.3
LLH	492	208	79	42.3	16.1
LMH	572	257	88	44.9	15.4
HML	492	229	76	46.5	15.4
HHL	482	234	72	48.5	14.9
HHH	614	298	88	48.5	14.3

Table 13. Carcass characteristics.

Treatment	Rib eye area	Back fat cover	Marbling score[1]	Carcass grade score[2]	Final body fat	Yield
	sq. in.	in.			%	%
LLL	12.7	0.76	6.1	8.2	23.1	59.9
LLH	12.6	0.70	7.1	9.4	24.9	61.4
LMH	12.4	0.89	6.3	9.2	27.0	64.1
HML	13.3	0.90	7.3	9.7	26.2	62.9
HHL	13.1	0.88	7.3	10.0	27.0	62.7
HHH	14.1	0.97	7.2	10.0	29.4	65.3

Table 14. Carcass characteristics when each lot had made a body weight gain of 400 pounds.

Treatment	Time required to gain 400 lbs.	Carcass weight	Carcass Composition fat	Carcass Composition protein	Marbling score	Carcass grade score	Rib eye area	Fat cover
	lb.	lb.	%	%	1	2	sq. in.	in.
LLL	273	666	25.3	16.2	6	8	12.7	0.76
LLH	239	660	24.4	16.4	6	9	12.2	0.65
LMH	206	666	25.3	16.2	6	8	11.9	0.79
HML	196	684	27.0	15.8	7	9	12.1	0.78
HHL	207	676	27.0	15.8	6	9	13.4	0.75
HHH	194	675	27.0	15.8	6	9	13.6	0.74

Table 15. Carcass characteristics when each lot reached low choice slaughter grade.

Treatment	Time required to reach low choice	Carcass weight	Empty body fat	Mar-bling score[1]	Rib eye area	Back fat cover
	days	lb.	%		sq. in.	in.
LLL	250	640	21.8	5.9	12.4	0.71
LLH	210	610	20.2	5.7	11.8	0.60
LMH	196	647	22.5	5.6	11.8	0.77
HM-	140	627	21.6	5.6	11.6	0.66
HH-	160	633	22.6	5.6	13.0	0.66

fed the various energy rations. Thus, even though high energy rations stimulate fat deposition when the cattle reach a given slaughter grade, there is little effect of energy level. Under the present system of grading, therefore, there appears little hope of altering the carcass of slaughter animals through altering the energy level in the ration. If the consumer is willing to accept a product with less fat, more protein, and less marbling, this product can be produced at the same weight as our present slaughter animals by feeding different energy levels.

PROTEIN NEEDS OF GROWING-FINISHING CATTLE

by

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Protein or, more specifically, nitrogen is one of the most expensive nutrients required in feedlot rations for fattening cattle. There is general agreement that most of the nutrients considered in ration formulation should remain in balance with each other for optimum feed utilization. The term "balanced ration" was coined by Henry as early as the turn of the century to mean "a combination of farm foods containing various nutrients in such proportions and smounts as will nurture the animal for 24 hours with the least waste of nutrients." Feed costs normally represent approximately 80 percent or more of the total cost of fattening cattle. The need for optimum ration formulation in the feedlot industry should be obvious.

It is a well-known fact that protein fed in excess of an animal's protein requirement can be utilized by the animal as a source of energy. However, protein supplements are expensive---much too expensive to use as sources of energy. Because high protein feeds or protein supplements are usually much more costly than those feeds used primarily for energy, minimum protein levels compatible with maximum ration efficiency understandably represent optimal or near optimal levels in a ration. When protein levels in the ration are too low, growth rate and feed efficiency will be impaired, resulting in expensive gains. When protein levels are too high, protein will be wasted, and expensive gains will result.

The economic significance of overfeeding protein can be illustrated by a simple example. Elevating the amount of protein in a feedlot ration by one percent of protein above the minimal amount needed (i.e., increasing the percent of protein in a ration from 12 percent to 13 percent if 12 percent is the minimum quantity needed) would increase feed costs by about sixty to seventy-five thousand dollars per year for a feedlot with a capacity of 20,000 head and a potential turnover of 2½ times a year. This is indeed a very sizeable figure and illustrates the influence proper ration formulation can have on feedlot projects.

Factors Influencing Protein Requirements

The protein requirements in a feedlot ration are thought to be a function of many variables and not a fixed figure for all conditions. Some of the factors which influence protein requirements (either percent in the ration or total quantity of protein) are:

1. Maintenance requirement or body weight
2. Rate of weight gain
3. Composition of gain
4. Quantity of feed consumed
5. Digestibility
6. Energy concentration in ration
7. Other

Maintenance

The protein requirement for maintenance is a function of body weight or size. There is a relationship between basal energy metabolism and endogenous urinary nitrogen excretion. Endogenous urinary nitrogen excretion represents the minimum essential nitrogen catabolism necessary for the maintenance of the vital body processes in life. This rate of nitrogen excretion is a function of metabolic body size, weight 0.75. For cattle, the estimates of endogenous nitrogen excretion would usually range from 0.08 to 0.1 gm of nitrogen or 0.5 to 0.63 gm of protein per unit of metabolic body size. Making appropriate adjustments for digestibilities and biological values of proteins and adjustments for metabolic fecal nitrogen losses, the estimated crude protein requirements (lb/head/day) for maintenance would be approximately 0.0055 weight 0.75 lb.

Body Gain

The quantity of protein needed for growth, above maintenance, depends largely on the rate of gain and composition of gain. The weight gain of relatively young, fast-gaining cattle will usually contain about 16 to 18 percent protein. For heavier cattle, the gain may contain about 14 to 16 percent protein or less. Obviously, many factors can influence the composition of gain and thus the amount of protein deposited per pound of weight gain. Making appropriate adjustments, the estimated crude protein requirement (above maintenance) per pound of weight gain would be about 0.55 lb, and the estimated digestible protein requirement per pound of weight gain above maintenance would be about 0.40 lb (University of California).

The level of activity or exercise of feedlot cattle has little or no affect on the protein requirement as long as the total calorie intake is adequate.

The protein requirements currently listed by the National Research Council for growing-finishing beef cattle are summarized in Table 1. The NRC levels represent what are regarded as minimal levels required for optimal performance with no allowance for a safety factor. As noted, the protein requirements are given both in terms of the percent needed in the ration and in terms of the total daily quantity needed. The requirements as listed in the table provide a simple method of expression, but are in some respects, an over simplification of the facts. As stated, many factors influence the actual protein and/or nitrogen requirement for any given situation. An important need exists for further quantification of the protein and/or nitrogen requirements in terms of all the numerous variables which may cause these requirements to vary.

To more accurately quantify the protein requirements for feedlot cattle of different weights and variable rates of gain, California workers have established protein requirement values for maintenance and gain of feedlot cattle as shown in Table 2. As noted in Table 2, digestible protein requirement values are listed for maintenance only for cattle varying in weight from 400 to 1100 lbs. and for rates of gain varying from 0.5 to 3.5 lbs. per day.

When using Table 2 to establish the protein requirement for a given animal gaining at a specific rate per day, one must add the digestible protein requirement for weight gain to that for maintenance to obtain the total daily requirement.

Table 1. NRC Protein Requirements of Growing-Finishing Cattle[1]
(Based on feed containing 90% dry matter)

Body Weight	Average Daily Gain	Daily Feed per Animal	Total Protein (% in ration)	Protein Digestible (% in ration)	Total Protein (Amount per day)	Digestible Protein (Amount per day)
lb	lb	lb	%	%	lb	lb
Calves finished as Short Yearlings						
400	2.3	11.8	11.0	8.2	1.3	1.0
600	2.4	16.4	11.0	8.2	1.8	1.3
800	2.2	19.4	10.0	7.5	1.9	1.5
1000	2.2	23.0	10.0	7.5	2.3	1.7
Finishing Yearling Cattle						
600	2.6	17.5	10.0	7.5	1.8	1.3
800	2.7	22.3	10.0	7.5	2.2	1.7
1000	2.6	25.8	10.0	7.5	2.6	1.9
1100	2.3	25.8	10.0	7.5	2.6	1.9
Finishing Two-Year Old Cattle						
800	2.8	23.3	10.0	7.5	2.3	1.7
1000	2.9	28.2	10.0	7.5	2.8	2.1
1200	2.7	31.0	10.0	7.5	3.1	2.3

[1] Adapted from National Research Council Publication No. 1137

Table 2. Digestible protein requirements for maintenance and gain of beef cattle.

Daily Gain (lbs.)		Body Weight (lbs.) 400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100
		For maintenance alone														
0	DCP[1]	0.30	0.33	0.36	0.39	0.41	0.44	0.46	0.49	0.51	0.54	0.56	0.58	0.60	0.63	0.65
		For gain alone -- must be added to maintenance for total requirement														
0.5	DCP	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
0.6	DCP	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
0.7	DCP	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
0.8	DCP	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
0.9	DCP	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
1.0	DCP	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
1.1	DCP	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
1.2	DCP	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
1.3	DCP	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
1.4	DCP	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56
1.5	DCP	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
1.6	DCP	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
1.7	DCP	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
1.8	DCP	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
1.9	DCP	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
2.0	DCP	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
2.1	DCP	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
2.2	DCP	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
2.3	DCP	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
2.4	DCP	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
2.5	DCP	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2.6	DCP	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
2.7	DCP	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
2.8	DCP	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
2.9	DCP	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16
3.0	DCP	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
3.1	DCP	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24
3.2	DCP	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28
3.3	DCP	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
3.4	DCP	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36
3.5	DCP	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40

[1] Digestible crude protein in lbs/head/day.

Quantity of Total Feed Consumed

The quantity of total ration consumed per day by an animal gaining at a specific rate is important in determining the percentage of protein required in the ration. A feedlot animal requires a specific quantity of protein each day, not a specific percentage. The percent of protein needed in the ration is determined by the total quantity of protein required and the total quantity of feed consumed.

Feedlot animals can obtain equal caloric intakes by eating smaller quantities of feed when fed high energy of "hot" rations than when fed conventional rations which are higher in roughage content. For this reason, considering only the percent of protein in the ration can be misleading. Using the protein requirement values given in Table 2, an 800 lb. steer gaining 3.0 lbs. per day would require 7.1 percent D. P. in his ration if he were consuming 24 lbs. of air dry feed per day. On the other hand, a 9.5 percent D. P. level would be required to supply the same quantity of protein if this same steer consumed a "hotter" ration totalling 18 lbs. of air dry feed per day.

Little work has been done to study the quantative requirements of protein on high concentrate or all-concentrate fattening rations. Studies by Weichenthal et. al. (1963) and Goodrich et. al. (1961) have shown that cattle fattened on conventional rations require no more than 11 percent total protein, which is in agreement with the levels reported by the National Research Council. However, Haskins et. al. (1967), studying all-concentrate rations, concluded that a 14 percent total protein level was needed with the levels of feed intake achieved in their study. Additional research work is needed in this area.

Digestibilities of Feeds

Some feeds, such as most cereal grains and roughages, are relatively low in protein content; whereas, other feeds, such as soybean meal, cottonseed meal and the like, are quite high in protein. Feeds vary greatly not only in protein content but also in the digestibility of their various nutrient components, including protein. Table 3 shows the approximate crude protein and digestible protein contents of some feeds commonly used in beef cattle feedlot rations. The protein digestibilities of the different feeds used will influence the level of total protein needed in a feedlot ration. Unfortunately, the digestible protein values given for most of the feeds are "apparent" digestibility values rather than "true" digestibility values. This is because of the complications associated with determining the metabolic fecal nitrogen fraction when conducting digestible protein values for feeds. The figures given in the NRC tables "are grossly in error" according to Preston (Feedstuffs, September 28, page 2, 1968). Work is under way at Missouri to determine the true digestibility of protein from various feeds fed to ruminants.

Protein to Energy Ratios

In swine and poultry rations, it is common to express protein requirements on the basis of protein to energy ratios in addition to the conventional methods of expressing protein requirements needed per day. Crampton (1965) has discussed the importance of maintaining nutrients, including protein, in balance with each other in ration formulation for all classes of livestock.

Increasing interest is developing in the area of ruminant nutrition for expressing protein requirements on the basis of protein to energy ratios. Preston (1965, 1967) determined that growing-finishing lambs required

Table 3. Protein content of feed.

Feed	Crude Protein	Digestible Protein
	%	%
Dry Roughages (90% dry matter)		
Alfalfa hay, 24% fiber	17.5	12.3
Alfalfa hay, 28% fiber	14.6	10.1
Alfalfa hay, 34% fiber	13.7	8.6
Alfalfa meal, dehyd. 20%	20.2	14.1
Alfalfa meal, dehyd. 17%	17.1	11.9
Barley hay	7.9	4.4
Barley straw	3.7	0.7
Bermuda grass hay, common	8.0	4.1
Corn cobs, ground	2.8	0.0
Corn fodder	8.0	4.4
Cottonseed hulls	3.9	0.2
Johnson grass hay	7.0	3.1
Meadow hay	8.2	4.9
Oat hay	6.4	3.8
Soybean hay	14.7	10.3
Sudan grass hay	11.5	4.4
Timothy hay, prebloom	12.2	8.2
Timothy hay, midbloom	7.7	4.2
Timothy hay, late bloom	7.1	3.5
Vetch hay	18.0	11.9
Silages (30% dry matter)		
Alfalfa, wilted	5.3	3.7
Corn, dent, well matured, well eared	2.4	1.6
Sorghum, sweet	1.9	1.0
Sorghum, dual purpose	2.4	0.6
Concentrates (90% dry matter)		
Barley grain	11.8	8.5
Barley grain, Pacific Coast	8.7	6.9
Beet pulp, molasses, dried	8.9	5.9
Brewers grains, dried	25.3	20.2
Citrus pulp, dried	6.6	5.2
Corn, dent, No.2	9.0	7.0
Corn and cob meal (ground ear corn)	8.3	6.1
Cottonseed, whole, pressed	25.1	18.1
Cottonseed meal, exp. or hydr.	40.1	32.4
Cottonseed meal, solvent	41.1	34.1
Fat (98% dry matter)		
Hominy feed, 5% fat	10.6	7.4
Linseed meal, exp. or hydr.	34.9	30.8
Linseed meal, solvent	34.7	30.5
Milo grain, Southwest	9.0	6.8
Molasses, cane, to 15% (71% D.M.)	3.0	0.0
Oat grain	9.1	6.9
Potato meal, dried	5.9	2.1
Rice bran	13.3	8.4
Soybean meal, exp. or hydr.	43.8	36.8
Soybean meal, solvent	46.3	42.5
Soybean meal, dehulled, solvent	50.0	46.8
Wheat grain, hard, red, spring	14.7	12.4
Wheat grain, hard, red, winter	13.0	10.9
Wheat bran	16.2	12.3
Wheat mixed feed (mill run)	15.3	12.7
Whey, whole dried	12.6	11.3
Yeast, Brewers, dried	43.1	37.2
Yeast, Touda, dried	46.9	40.2

The values listed above were largely taken from NRC publications 1137 and 1232/

22 gm of digestible protein per 1000 kcal (megcal) of digestible energy (D. E.) for optimum performance. The protein to calorie ratio for mammalian species, differing in size as widely as rats and cows is relatively constant for adult animals at maintenance living, regardless of species or size. The illustration of this can be seen in Table 4.

Humans, for example, require 28, 23, 21, and 19 gm. of D. P. per megcal of D. E. when 25, 35, 72, and 100 percent of the adult metabolic body weight is attained, respectively.

Preston, (1966), proposed the protein to energy ratios shown in Table 5 for feedlot cattle. The protein to energy ratios given in the table were derived using the protein requirement values listed in the NRC requirements. Consequently, any consistent bias in the NRC requirement values would be reflected in the figures presented.

Urea Feeding

It has been known for a long time that cattle can utilize urea or other non-protein nitrogen sources to meet part of their protein requirements, due to the microbial systhesis of protein in the reticulo-rumen under proper conditions. Proper conditions would include an adequate supply of phosphorous, sulfur, and trace minerals, a source of readily available carbohydrates, frequent feeding, a proper adjustment period, among other things. An excellent review of urea utilization by ruminant animals was presented by Tillman(1967).

A monumental amount of research work is available in the literature on feeding urea and other non-protein nitrogen sources to ruminants. Nevertheless, the many factors limiting the amount of non-protein nitrogen which can be utilized efficiently in ruminant rations is not well understood.

From the discussion in the preceeding pages it is obvious that some feedlot rations may require substantial amounts of supplementary protein whereas, others may require only small quantities, due to the protein content of the feeds used and other factors. Urea feeding has received much attention, justifiably, in feedlot rations because urea is a cheaper source of nitrogen than natural protein supplements.

On the basis of present prices, economics dictates that is is usually profitable to use some urea in feedlot rations. The level of urea feeding is important. In some cases, particularly where small quantities of supplementary nitrogen are needed, urea might very adequately serve as the sole source of additional nitrogen in feedlot rations. In general, most research studies with feedlot cattle have shown that the addition of excessive urea levels will depress feed intakes, rates of gain, feed efficiency, and feedlot profit.

Considerable research at OSU and elsewhere would permit one to establish some general guidelines for satisfactory use of urea in most feedlot situations. Reasonable guidelines could be listed as follows:

1. Feed urea to supply up to 15-25 percent of the total crude protein in a fattening ration.
2. Feed 0.1-0.2 lbs. of actual urea per head per day.
3. Feed 0.28-0.56 lbs. of total curde protein from urea per day.
4. Feed not more than 0.5-1.0 percent urea by weight in the total air dry feed (90 percent dry matter) consumed. A level of about 0.6 percent urea is currently recommended in Oklahoma for most high concentrate feedlot rations.

Table 4. Grams of digestible protein required daily per megcal of digestible energy for adult maintenance.

	Man	Cow	Horse	Pig	Sheep	Rat
Adult weight(Kg)	70	454	454	228	73	0.55
Protein/megcal D.E.	19	19.3	19.7	18.1	19.1	19.5

Table 5. Protein to energy ratios required in the rations of growing-finishing cattle.[1]

Daily gain	Grams digestible protein required per megcal of digestible energy
Kg	
maintenance	20.8
0.5	24.7
1.0	26.4
1.5	27.2

[1] Preston, 1966.

Obviously, the above guidelines are only generalizations and may not necessarily apply in a number of situations. Many questions about urea feeding remain unanswered.

When comparing the relative economics of feeding urea at various levels versus natural protein supplements, it is important to bear in mind that a consideration of relative feed costs only does not necessarily reflect the actual and complete economic facts of feeding cattle, due to the 14-15 cents per head per day overhead cost (above feed costs) associated with feeding cattle in most of the commercial feedlots in Oklahoma at the present time. When using urea, one must be cautious not to elevate the urea levels to the point where rates of gain will be materially reduced and feeding time prolonged. A small saving in feed costs may be more than offset by the increased overhead costs incurred when carrying the cattle for a longer period of time in order to achieve the same total gain and/or grade. The entire picture must be kept in proper perspective.

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MINERAL NUTRITION FOR RUMINANTS

by

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Many localized areas in the world have been found to be unsatisfactory for the raising of beef cattle and other ruminants because of severe endemic disorders. In many cases these disorders result from a deficiency of one or more minerals and once the deficiency or deficiencies are corrected normal livestock production is possible.

The detection and remedy of acute deficiencies are the easier aspects of mineral nutrition; the difficult problem concerns borderline deficiencies. In such cases no outward symptoms appear, and , to all but the closest observers, the performance of animals might appear to be satisfactory. However, closer introspection reveals that the metabolism rate of an animal slows down in compliance with the level of the limiting mineral. Depending upon the function of the mineral involved, one might observe somewhat slower than maximum growth, less resistance to infection, less milk production, poorer breeding efficiency, abnormal skin conditions, or lowered feed conversion.

The purpose of this paper is to discuss the functions of various minerals and to discuss the possibilities of deficiencies of individual trace minerals under various feeding systems.

Proof of the essentiality of a trace mineral rests upon the effects of variations in dietary levels upon tissue or skeletal growth, skeletal abnormalities, and their functioning in various enzyme systems, which are associated with the general well being of the animal. The following minerals are established dietary essentials for ruminants:

A. Major Minerals: Calcium, phosphorus, magnesium, sodium, potassium, chlorine, and sulfur.

B. Trace Minerals: Cobalt, copper, iodine, iron, manganese, and zinc. There is excellent evidence that selenium should move into the "essential" list while molybdenum is of doubtful importance.

General Functions and Deficiency Symptoms

A. The Major Minerals

Calcium. Calcium is one of the important minerals for cattle and has the following functions in the body:

1. Formation and maintenance of the skeletal structure.
2. As ionic calcium, it functions in blood clotting.
3. Neuro-muscular action.
4. Activation of enzymes.

A severe deficiency of calcium in the very young animal results in rickets. As most feeders use animals which are essentially mature as regards skeletal size, they are more interested in the effects of low-calcium diets on this animal. Using calcium-free diets, we have fed sheep 182 days before they died. The greatest effect was upon the bones, which were thin and easily broken.

Feedlot rations contain high levels of grain, which are low in calcium. Thus supplemental calcium is needed in most of the feedlot rations used in Oklahoma and the Great Plains. We feel the requirements of feedlot cattle fo for calcium is about 0.4 percent of the diet. If young calves are used, the level should be increased. Table 1 lists the mineral requirement of feedlot cattle. As indicated later, mineral balance is an important consideration in feedlot cattle.

Phosphorus. Phosphorus is an important nutrient in cattle feeding because of its many functions as follows:

1. Formation and maintenance of skeletal structure.
2. Involved in the metabolism of carbohydrates, fat and protein.
3. Functions in energy transformation.
4. Functions in nucleic acid.
5. Functions in acid-base balance in the body.

Deficiency affects bone formation, appetite, reproduction and growth of cattle. Under range conditions, it is one of the most critical inorganic nutrient for cattle production. However, it is not a critical nutrient under feedlot conditions. Many grains either furnish enough phosphorus or are borderline as regards requirements. It appears that the requirements for feedlot cattle is no higher than 0.3 percent of the ration.

Sodium and Chlorine. Sodium chloride (common salt) should be added to all feedlot rations as all natural diets are deficient. A great reduction in appetite and feed conversion results when salt is not included in feedlot rations. The level needed is probably around 0.25 to 0.50 percent of the diet.

Magnesium. Magnesium is present in the body in smaller amounts than are calcium and phosphorus, but it is closely related with these elements in metabolism and distribution in the body. The writer knows of no experimental evidence supporting the idea that additional magnesium is needed in feedlot rations.

Potassium. The writer knows of no evidence supporting the idea that supplemental potassium is needed for the typical feedlot rations used in Oklahoma.

Sulfur. Sulfur is contained in protein, vitamins and other components in the body; the nitrogen: sulfur ratio in beef protein is 15:1. When urea is used in fattening rations, one should consider the sulfur level of the ration and with the idea of adjusting the N:S ratio to 10:1.

B. The Trace Minerals

Cobalt. Ruminants utilize cobalt for the synthesis of vitamin B_{12}, thus deficiency symptoms are essentially those of a vitamin B_{12} deficiency as found in the non-ruminant. Ruminants grazing forages containing less than 0.07 ppm of cobalt lose appetite, become listless, weak, anemic, and die. The lowering of the B_{12} content of the blood and tissue, especially the liver, is the only specific deficiency symptom. As vitamin B_{12} analyses are difficult, the easiest means for diagnosis of a cobalt dificiency rests upon response of the animal when fed dietary cobalt. Dificient animals respond rapidly. Appetite improves within a few days and the animal gains in weight and condition within two to three weeks. The use of cobalt oxide pellets, which when swallowed, are trapped in the reticulum and release about 1 mg. of cobalt/day makes diagnosis simple and easy under many management conditions.

Ruminants require a high level of vitamin B_{12} because it is a part of an enzyme system involved in the utilization of propionic acid, a major end-product of bacterial carbohydrate degradation in the rumen. Since

Table 1. Estimate of optimum mineral levels for cattle.

Calcium	0.4%	Copper	10 ppm
Phosphorus	0.3%	Iron	30 ppm
Magnesium	0.1%	Manganese	30 ppm
Potassium	0.5%	Zinc	30 ppm
Sodium	0.2%	Cobalt	0.1 - .5 ppm
Chlorine	0.2%	Iodine	0.2 - .4 ppm
Sulfur	0.15%	Molybdenum	1 ppm
		Selenium	0.1 ppm

grains tend to increase the proportion of propionic acid in the rumen fluid, such diets will increase the animal's requirements for vitamin B_{12}.

Copper. If the vegetation supplies less than 5 ppm of copper, adult animals suffer from "falling disease", which is characterized by loss of weight, anemia, and sudden death caused by cardiac failure. Infertility in cows is frequent. Also calves from mothers in copper-deficient areas show poor growth, fading of hair coat, stilted gait resulting from failure of bone deposition in the matrix. Also there is demyelination of the myelin sheath resulting in an outward condition called swaybeck. Australian workers have reported an enzootic ataxia in which there is extreme weakness in the hindquarters resulting in a swaying; the animal appears to be sitting up. Changes in growth and physical appearances of hair, fur or wool have been found in ruminants: these lose crimp and become "steely". There are more sulfhydral groups than in normal hair, fur, or wool suggesting that copper is necessary for the formation of disulfide groups. The exact mechanism which causes this situation is still unclear.

"Falling disease" in sheep or cattle is caused by the replacement of the elastic fibers by collagenous tissues. Copper seems to be necessary fo for the formation of desmosine, the significant protein in elastin. Thus the elasticity of the walls of the aorta, heart, and other parts of the vascular system is reduced. Rupture of the aorta is common in acute copper deficient cases.

Bleaching of the hair coat probably results from failure of melanin formation, copper being concerned with specific enzymes necessary for melanin formation.

Copper deficiency symptoms also appear in many parts of the world, where indigenous forages contain normally sufficient amounts of copper. The difficulty concerns the fact that plants in these affected area arise from soils having excess levels of molybdenum or sulfur. Results of researchers in Australia, England, Scotland, Holland, and the United States indicate that there is an interrelationship of copper, molybdenum, and sulfur in animal nutrition. High levels of molybdenum, a characteristic of many peat soils in the world, will precipitate a copper deficiency; such a condition is often designated as molybdenum toxicity. The condition will respond to copper supplementation. The added copper may be given as a drench, in a salt supplement, or intramuscularly using a paste of copper glycinate. High levels of sulfate in the forage will also increase copper requirements; this is characteristic of many of the forages in the reclaimed lands of the Netherlands.

Iodine. Iodine is necessary for the formation of thyroxine, a hormone concerned with the regulation of metabolic rate. A deficiency of iodine results in an enlargement of the thyroid gland, a condition called goiter, and lowered basal metabolic rate. Goiter results because of a compensatory hypertrophy of the thyroid gland in response to a stimulus to produce thyroxine.

Iodine deficiency is an area problem, and Oklahoma is not usually considered as a part of the area in which the soil, water, and plants are deficient. However, we must take a fresh look at iodine: It has been shown that high levels of dietary nitrate reduce thyroxine secretion and that added dietary iodine will alleviate the condition. Also it appears that there may be an association of Vitamin A deficiency symptoms in cattle fed corn silage rations with hypothyroidism and that this might be prevented by increasing the level of dietary iodine. There is evidence that iodine should be a part of the trace mineral supplement used over a variety of ruminant management conditions. Levels of 0.2% - 0.4 ppm will meet the requirements of ruminants.

Iron. Iron functions in many enzyme systems in the body and is a part of the hemoglobin in red blood cells. Deficiency results in a lower level of hemoglobin, and the condition is referred to as nutritional anemia. Anemia may occur at any time during the life span of animals, but is most prevalent in young suckling mammals. As milk is a poor source of iron and copper, anemia is most likely to occur when it is a major component in the diet. The young ruminant iron-deficient diets show the following sequence of outward symptoms: (a) feed refusal, (b) scouring, (c) paleness of the buccal membranes and of the conjunctiva, (d) reluctance to move, (e) high pulse rate with slow return to normal after the stress of exercise and (f) progressive loss of appetite. Hemoglobin level drops steadily from a normal value of 12-13% to as low as 4 to 5% resulting in hypochromic, microcytic anemia.

Manganese. A deficiency of this element in ruminants results in the following symptoms: (a) poor fertility, (b) leg deformities (shorter bones), (c) poor fertility, (d) increased incidence in the herd of abortions, and (e) a dull haircoat.

Manganese is known as an enzyme activator and in vitro will activate the following enzyme systems: arginase, cystine disulhydrase, carnosinase, deoxyribonuclease, thiaminase, and others. The element appears to be requi required for oxidative phosphorylation in mitochondria. It is also involved in fatty acid synthesis, amino acid transport, and cholestrol synthesis.

Zinc. Zinc functions in several enzyme systems, but there are no apparent relationships with these and the deficiency symptoms exhibited. It is a part of carbonic anhydrase, which is necessary for the formation of carbonic acid from water and CO_2; the reaction is also reversible. It is also found in other important enzyme systems. Red blood cells contain relatively high levels, thus loss of blood by parasites or other means would increase dietary needs. Prostate secretions contain high levels and testicular atrophy results in zinc-deficient males.

Georgia workers, using a purified diet, produced zinc deficiency in ruminants and the outward symptoms were as follows: (a) slightly red and imflamed nose and mouth, (b) mild swelling above the rear feet in front of the fetlock, (c) loss of hair on the rear legs and rest of the body, (d) breaks in the skin around the hoofs, (e) rough and scaly skin especially on the rear legs, (f) and a dull, listless appearance. Similar lesions have been noted in beef and dairy cattle kept under natural conditions; cattle grazing the Berbice savannahs have many of the above parakeratotic lesions which cover over 40 percent of the body. Response to zinc given orally (2 gm/week) or by subcutaneous injection (1 gm/week) was rapid; new growth of hair appeared within one week and the animals appeared normal within three weeks. The unsupplemented control animals in the meantime became steadily worse.

In Finland, the writer saw a number of dairy cows which exhibited many of the above symptoms. These cows (a) produced less milk, (b) made less efficient use of their feed, (c) required more services for conception and (d) had more abortions than animals not having these abnormalities. Zinc supplementation gave a prompt alleviation of the parakeratotic lesions and disappearance of the other conditions in time.

There is no doubt that zinc is an important element in ruminant production. Requirements for ruminants is about 30 ppm. It is my judgement that it should be included in all trace mineral mixtures for cattle.

Selenium. Until 1940, selenium was primarily considered toxic for animals. It has been found since then that selenium will prevent myopathy (muscular distrophy, white muscle disease, etc.) occuring in many areas of the world. Myopathy is found in lambs and calves which have been born of mothers on selenium-deficient pastures. Selenium treatment to the dam and either vitamin E or selenium treatment to the young seems to prevent the condition.

Selenium and vitamin E are both powerful antioxidants at the cellular level. It appears, however, that their roles in nutrition extend beyond this. Selenium is probably involved in specific proteins of the body which are necessary for the retention of vitamin E.

In Oklahoma work with sheep using purified diets, it was shown that animals receiving neither vitamin E or selenium die from myopathy in a short period. Selenium supplementation delayed the development of myopathy in the breeding animals and increased survival time. Animals receiving vitamin E, but no selenium, survived for a long period but their lambs did not survive; typical myopathy symptoms were present in all lambs and all died shortly after birth. We feel that this could be an indirect result of vitamin E deficiency; it being possible that vitamin E did not pass through the placenta or into the milk. However, one cannot rule out the possibility these resulted from a selenium deficiency. Animals receiving both vitamin E and selenium have survived for a long period and have reproduced successfully.

In the dystrogenic areas of the world, other symptoms of selenium deficiency have been noticed in ruminants such as reproductive inefficiency, unthriftiness and paradental disease. However, no critical experiments have been performed to indicate if this is a direct result of selenium deficiency.

It now appears that ruminants in the midsection of the United States are consuming feeds which contain 0.5 to 2.0 ppm of selenium, if, of course, locally-grown feeds are used. In contrast, ruminants on the east or west coast consume locally-grown feeds containing much lower levels: There are some estimates of 0.2 ppm while there are times or places where there is less than 0.1 ppm. Results of recent research indicate that ruminant dietary levels of selenium should be at least 0.1 ppm and not less than 0.05 ppm.

Cornell workers, using chicks, have found that 0.01 ppm of selenium is essential for the prevention of mortality in chicks even though the diet contains high levels of vitamin E. They have also shown that as the vitamin E level of the diet decreased the selenium requirements increased. On the basis of their data, they have recommended that the dietary level of selenium should be 0.15 ppm. It is possible that a ruminant would also benefit from such a level, particularly since the dietary vitamin E level varies when all management conditions are considered. Toxicity occurs when rations containing over 5 ppm are fed.

Mineral Interrelationships. The author has had an interest in this aspect of nutrition for many years and as a result of this interest, he and his students, using an old idea, have constructed the carrousel shown in Figure 1, 2, and 3. We have listed all mineral interrelationships which have come to our attention, regardless of how important or unimportant an interrelationship may be. Undoubtedly, there are omissions and mistakes, but it is felt that such an exhibition contributes to a better understanding of the overall problem of mineral interrelationship in nutrition.

If an arrow points from a specific mineral, e.g., calcium, to another one, e.g., zinc, an excess dietary level of calcium will interfere with the utilization of zinc. If, as in the case of calcium and phosphorus, there are two arrows on the same line, the two elements are mutually antagonistic.

As was indicated previously in this paper, there are times when an interrelationship of two minerals precipitates conditions of great economic importance. For example, limestone is an economical filler for commercial livestock rations. During the 1950's, the practice of adding too high levels of calcium in the rations of chicks and swine resulted in widespread instances of parakeratosis. As is evident on the carrousel, high levels of dietary calcium interfered with the utilization of dietary zinc, thereby precipitating a deficiency of zinc, thus the parakeratotic lesions.

The important interrelationship of copper, molybdenum, and sulfate was also discussed earlier and can be discussed in relation to my interesting experience with calves: The effects of high level of dietary sulfate upon reduced dietary utilization copper was counteracted by feeding supplemental copper, but in the process, copper was increased too much, thereby resulting in a severe zinc deficiency. This experience illustrates the importance of judicious use of all minerals when supplementing practical rations.

Many other relationships could be cited but these are shown on the carrousel.

Trace Mineral Chelation. The word chelation is derived from the Greek word "chele", meaning to claw. In the case of trace minerals, the chelate surrounds the metal holding it in two places. Chelates may be sequestering agents which keep metals from forming insoluble metal complexes.

When considering chelating metals in nutrition, it must be remembered that the affinity of a chelate for metal may be expressed quantitively as a stability constant. Perhaps we can understand this by considering the reaction of a chelate (C) and a cation (M).

$$M + xC = MC_x$$

The equilibrium constant (K) for the reaction may be expressed as follows; enclosed figures are for activities of the ions:

$$K = \frac{MC_x}{(M)(C)^x}$$

However, the activities of chelating ions are difficult to measure. Thus molar concentrations are substituted for activities and an apparent formation constant, K_f, is used instead of the equilibrium constant:

$$K_f = \frac{MC_x}{(M)(C)^x}$$

The log of K_f is then the stability constant.

Figure 1. Mineral Interrelationships In Animals

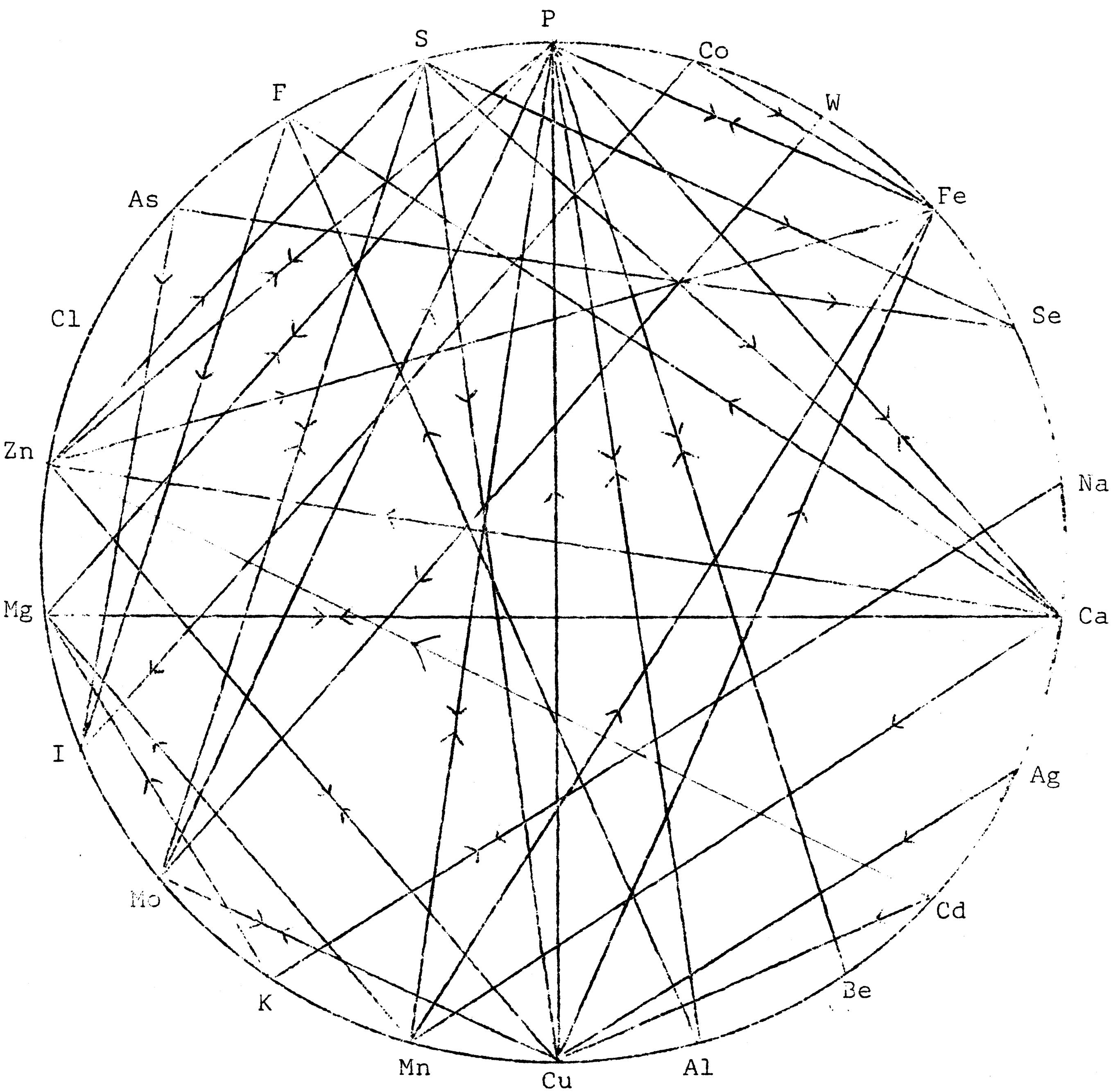


Figure 1 cont.

Phosphorus: (a) Ca, Mg, Mn, Zn, Fe, Al and Be interfere with the absorption of P, as well as the opposite being true, due to the formation of insoluble phosphates. (b) Low Cu-high Mo intakes increase the loss of body P (copper is required for phospholipid synthesis).

Calcium: (a) High Ca levels in the diet reduce the absorption of Mn, Zn and F. (b) An excess of either Ca or P interferes with the absorption of the other due to the formation of insoluble tricalcium phosphate. (c) Large intakes of either Ca or Mg increases the urinary excretion of the other; but, both Ca and P prevent the absorption of excess Mg. (d) SO_4 increases the excretion of Ca.

Copper: (a) Cu is required for the proper metabolism of Fe. (b) Cd and Ag increase the severity of Cu deficiency. (c) High dietary Zn reduces liver stores of Fe and Cu while low Zn favors excess storage of Fe and Cu. Excess Cu causes low storage of Zn. (d) Mo limits Cu storage in the presence of adequate sulfate. Sheep with high liver Cu have low Mo levels and Cu toxicity may develop with low Mo intakes.

Sulfur: (a) Sulfate - S limits Cu and Ca storage and protects against Se toxicity. (b) High Zn increases fecal S. (c) SO_4 decreases liver Mo.

Molybdenum: (a) Tungstate (W) increases urinary excretion of Mo.

Cobalt: (a) Cobalt increases the urinary excretion of I. (b) Fe accumulates during Co deficiency (Co needed for Fe metabolism).

Iodine: (a) As and F have goitrogenic activity.

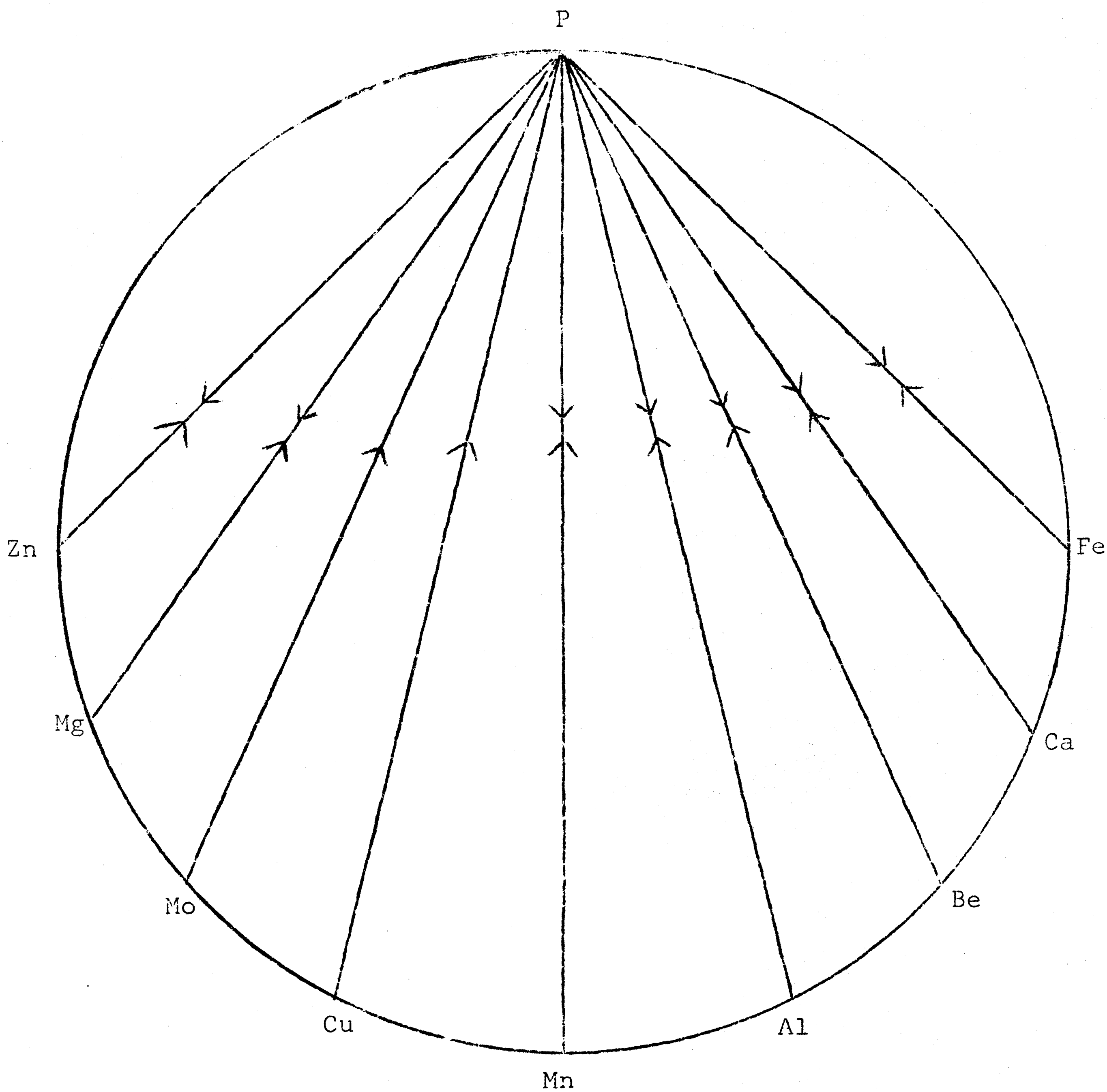
Flourine: (a) Ca and especially Al salts protect against F toxicity.

Selenium: (a) SO_4 and As reduce Se toxicity.

Sodium - Potassium: (a) Deficiency symptoms of either of these elements are aggravated by an excess of the other. The high K content of forage may explain the high salt requirement of Herbivera.

Manganese: (a) High Mn interferes with Fe utilization. (b) High Mn lowers serum Mg.

Figure 2. Phosphorus Interrelationships

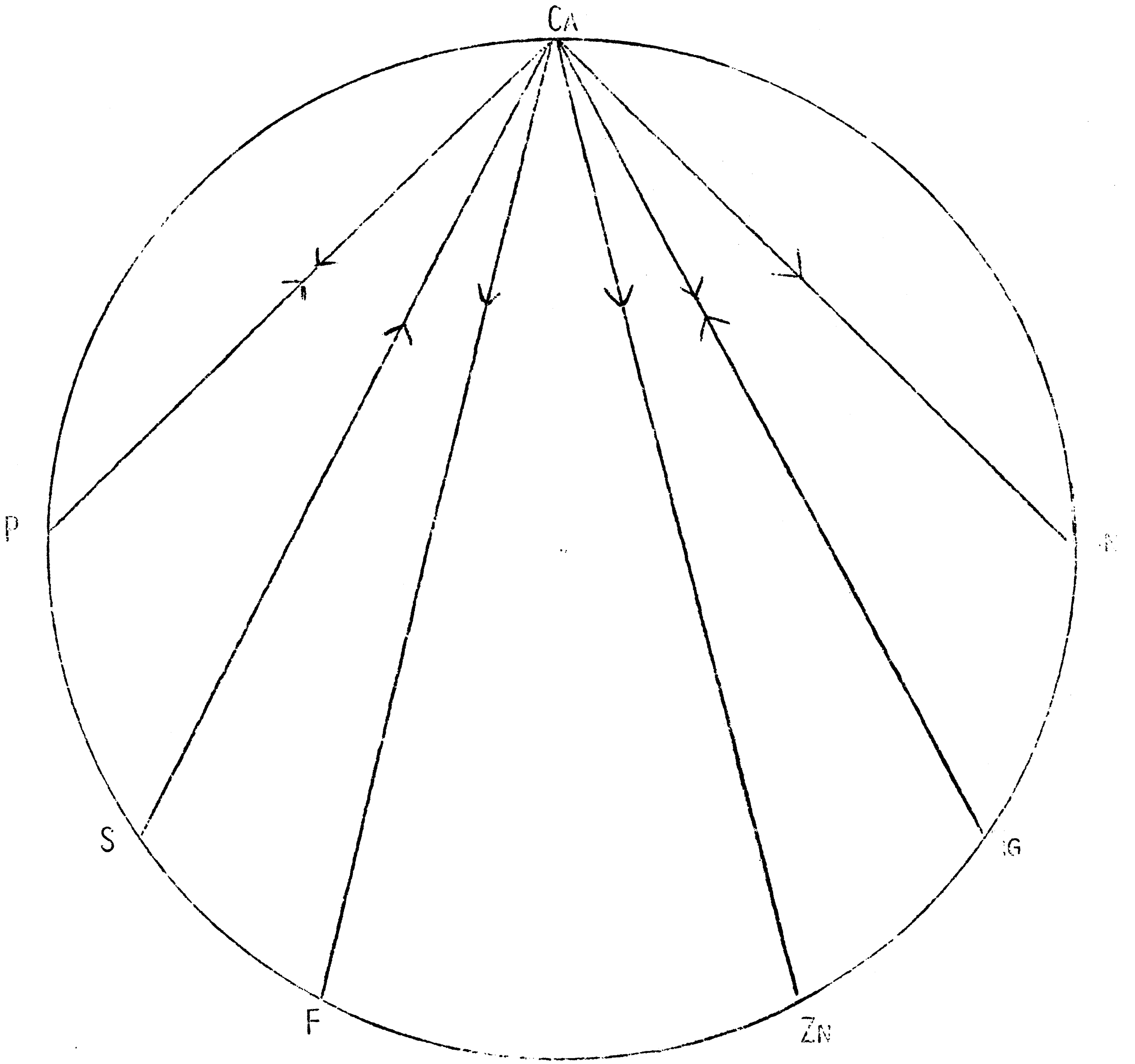


Mg, Mn, Zn, Fe, Al and Be form insoluble phosphates, thus reduces the availability of both.

Low Cu-high Mo increases the loss of body P. Copper is also required for phospholipid synthesis.

An excess of either Ca or P interferes with the absorption of the other.

Figure 3. Calcium Interrelationships



High dietary Ca reduces the absorption of Mn, Zn and F.

Large intakes of Ca or Mg reduces the utilization of the other.

An excess of either Ca or P reduces absorption of the other due to $Ca_3(PO_4)_2$ formation.

Sulfate-sulfur limits Ca absorption, possibly because of CaS formation.

Because of their great affinity for metals, chelates have found wide use in medicine to counteract heavy metal poisoning. A common remedy of lead poisoning is the infusion of calcium ethylenediaminetetraacetate (Ca-EDTA).

As mentioned earlier, zinc from vegetable sources is not well utilized by non-ruminants because zinc is chelated by phytic acid. When a sodium salt of EDTA is fed, growth of chicks is improved because zinc replaces sodium and forms a Zn-EDTA chelate which has a higher stability constant than the Zn-phytate chelate. California workers reported that a level of 100 ppm of Na-EDTA in a diet for chicks, in which zinc was suboptimum, was equivalent to about 8 ppm of zinc. In combination with a small amount of zinc, 100 ppm of the chelate was equivalent to 19 ppm of dietary zinc. These data indicate that the chelate improved the effectiveness of the zinc already in the diet and also of the added zinc. It appears that the dietary zinc must have been made unavailable by some factor or factors.

Laboratories in California, South Carolina, Missouri, and others have conducted much research on the chelation of zinc in poultry diets. California workers have used 28 or more chelating agents and found that EDDADP and HEDTA were as good for this purpose as EDTA. However, DHEG, CDTA, and TETA were ineffective in improving zinc utilization. Using the stability constants of chelates, the California workers reported that maximum growth activity was found with compounds having a stability constant of about 14. If the stability constants were greater than 14, which is that of EDTA, the chicks showed greatly reduced growth activity, indicating that the zinc could not be removed from the chelate. However, if the stability constant was less than 14, the chelate was also ineffective, presumably because the chelate was unable to remove Zn from the Zn-phytate chelate. Thus, it appears that the efficacy of a chelate may be a matter of relative stability constants.

It is apparent that EDTA can be absorbed by chickens and turkeys. It also appears that the zinc is solubilized by the addition of EDTA to the diet and that some part, and possibly a major portion of the chelated mineral, is absorbed in the chelate form. There are also indications that EDTA improves the utilization of rations marginal in copper or manganese and that the mechanism is similar to that for zinc. However, if EDTA is added to diets marginal in iron, hemoglobin levels are decreased, which can be overcome by additional dietary iron. It appears that the Fe-EDTA has a stability constant greater than that of tissue and blood components, so that iron is not released for the chelate.

Published works on the use of chelated minerals in ruminant nutrition are scarce. United States Patent #2,960,406, which was issued to B. P. Cardon and assigned to Erly-Fat Livestock Feed Col, Tuscon, Arizona, concerns chelated minerals in feed-stuffs for ruminants: The authors of the patent claim that ruminant feeds of low digestibility, which have marginal trace mineral deficiencies, were improved in digestibility by the use of chelated trace minerals. It was indicated that the preferred gro group of chelating agents was EDTA. It was shown that chelation increases the solubility of cobalt, iron, manganese, zinc, and possibly in rumen fluid. Whether this is of significance as regards the growth of rumen bacteria as well as in the animal growth is not known to the author. Obviously there is need for devinitive work in the area of chelates in ruminant nutrition.

Georgia results indicate that the Zn-EDTA chelate is absorbed by ruminants but that the major portion was excreted in the urine. Tissue concentration of radioactive zinc was not improved by the EDTA chelate. Iowa results indicate that some chelates reudce fermentations in the rumen, thus care must be used in the selection of these for use in ruminant nutrition. EDTA appears to cause diarrhea in cattle but the levels needed for trace mineral chelation would not be expected to have a harmful effect.

It must be pointed out that there are many chelates in the diet as well as in the animal's body. Citric acid is an excellent chelate. Indiana results indicate that citric acid may be a growth promotant in ruminant diets containing high levels of grain sorghum, diets causing a high incidence of urinary calculi. The possibility that this results from a chelating effect on certain minerals cannot be disregarded. Glycine is also an excellent mineral-chelating agent and lysine will improve that absorption of calcium and possibly trace minerals. Phytic acid is an excellent chelating agent and its effect upon zinc has been discussed. Phytic acid will also interfere with the utilization of calcium and phosphorus.

It appears that manganese is chelated by bile salts and perhaps certain amino acids prior to absorption. Heme chelates iron, and as mentioned before, EDTA can cause anemia possibly because of the high stability constant of the EDTA-Fe chelate, once it has taken the iron from the porphyric complex. Thus chelates and the chelating phenomenon has been known for years. It is conceivable that by the selection of proper chelates one could improve the utilization of each trace mineral by ruminant. Further research must be done before this becomes a recommended practice.