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EC72-225 Beef Feeding Suggestions for Finishing Cattle

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EC 72-225

Beef Feeding Suggestions

FOR FINISHING CATTLE

Extension Service
University of Nebraska-Lincoln College of Agriculture Cooperating with the
U. S. Department of Agriculture and the College of Home Economics
E. F. Frolik, Dean J. L. Adams, Director

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Beef Feeding Suggestions for Finishing Cattle

Paul Q. Guyer, Walter R. Woods, Terry J. Klopfenstein[1]

INTRODUCTION

Our knowledge of ration formulation has progressed a long way but we still have a lot to learn about what takes place during digestion, absorption and metabolism.

Rations can be formulated that will produce consistently rapid and efficient gains and enough knowledge is available to permit a high level of management of the nutritional program.

A wide variety of feedstuffs can be used and, with careful ration and cattle management, major changes can be made in ration ingredients during the finishing period without causing digestive disturbances or reduced rate of gain.

This circular will discuss rations for finishing cattle. It will apply to rations for steers weighing from 650 pounds up and for heifers weighing 550 to 600 pounds and up.

NON-NUTRIENT FACTORS INFLUENCE RATION SELECTION

Several factors not directly involved in nutrition influence ration formulation. These include:

1. Performance of cattle. Maximum rate and efficiency of gain should be your goal once cattle are started on the finishing ration. To obtain these results finishing rations should contain minimum roughage levels.

2. Stage of feeding period. Digestive disturbances associated with starting cattle on feed will be reduced when higher levels of roughage are fed at the beginning of the feeding period. A series of four or more rations with decreasing roughage levels can be used to start cattle on feed safely and quickly.

3. Feeds available. Feeds available on the farm or in the area should be considered first. Cornbelt feeders must not overlook profit potentials in milo, wheat or by-product feeds such as beet pulp and hominy. On the other hand, for efficient use of storage and labor, feeds used should be limited in number.

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Figure 1. Uniform mixing helps minimize nutritional problems.

4. **Weighing, mixing and handling facilities.** Facilities influence the number of ingredients, the type of processing, the amount of roughage and the choice of supplemental feeds used in the ration.

Precise control and uniform mixing (Figure 1) help minimize nutritional problems, contribute toward effective use of concentrated supplements and premixes and reduce the need for roughage in the ration.

Farm elevators and grain storage are usually built to handle only a limited number of ingredients. This will limit the number of feedstuffs fed and will reduce the opportunity to utilize by-product feeds that are good buys. Design of storage facilities may also be a limiting factor in choice of ration ingredients or the form in which they are fed.

5. **Mixing or handling characteristics of feed.** Some ingredients are hard to handle. Others give poor physical properties to the ration. One example is the ability of urea to absorb moisture from the air. High urea dry supplements will "set up" when stored in bins in the more humid areas of Nebraska. High urea supplements must either be in liquid form or be handled in sacks to prevent "caking" if stored for several days at the feedlot.

Another example is a dusty ration which needs addition of molasses, fat or silage to reduce wind loss and to increase palatability.

METHODS OF FORMULATING RATIONS

Rations will be calculated on a dry matter basis rather than 90% dry matter which has been traditionally used. We are making this change because of the wide variation in moisture content of feeds now fed to beef cattle and the increased simplicity of converting to and from a dry matter basis compared to a 90% dry matter standard.

There are two methods of putting rations together. One is to feed roughage and supplement on the basis of a predetermined amount per head per day and feed the grain according to appetite. The other is to mix ration ingredients on the basis of percentage of the ration. This method is used frequently in larger feedlots.

When a fixed amount of roughage and supplement is fed, the mix varies from day to day as the amount of grain fluctuates. This variation in the rumen content makes adaptation of rumen microflora difficult. On the other hand, this feeding system provides uniform intake of supplemental nutrients and feed additives from day to day.

Formulation on the basis of percentage of ingredients provides a feed mixture essentially the same from day to day. Thus, there is no problem of bacterial adaptation once the cattle are on the final finishing ration.

However, this type of formulation results in variable feed additive intake as the total feed consumed fluctuates from day to day. When all points are considered, however, this method should give more consistent results than feeding specific amounts of roughage and supplement daily and varying the grain.

The nutrient balance should be calculated on the basis of percentage requirement rather than on the basis of a daily requirement. This contributes to proper nutrient balance of the ration even though cattle consume more or less feed than an average daily requirement shown in requirement tables.

COMPUTER FORMULATION OF RATIONS

Rations can be formulated by computer in a fraction of the time it takes by hand (Figure 2). Where there are several competitive feed ingredients, the computer can be used to formulate least cost rations. Computer formulation of beef rations will be used more in large operations which buy feeds frequently than in operations where much of the feed is produced and stored on the farm.

RATION INGREDIENTS

Rations are made of several ingredients which can be subdivided in various ways.

Figure 2. Computers can formulate rations quickly and efficiently.

One way is as follows: energy concentrates, roughages and supplements (designed to provide proteins, minerals, vitamins, hormones and antibiotics). Most energy feeds also provide some protein and all natural protein feeds provide some energy (this is not the case with urea or similar non-protein nitrogen compounds providing nitrogen which is transformed into protein by bacteria in the rumen). Roughages may provide some energy as well as protein besides having special physical properties which are important.

Energy Concentrates

Corn and milo are the main energy sources for finishing rations in Nebraska. Wheat and several by-product feeds will be available at competitive prices from time to time in some areas of the state.

The relative feed value and suggested restrictions for several energy sources are shown in Table 1.

Processing Grains—Grain is processed primarily to change it to a state that will contribute to maximum digestion and utilization.

Grain processing does not influence rate of gain unless it is overprocessed (finely ground corn, grain cooked too long) to the point that

Table 1. Energy sources for finishing rations.

Feedstuff	Net energy for gain	Value compared to corn	Ration restrictions
	(Mcal[a]/lb)	(%)	(maximum %)
Animal fat	1.41	160–180	5
Barley	.64	88–90	100
Beet pulp	.60	88–95	50
Corn	.67	100	100
Hominy feed	.68	95–98	20
Millet	.65	90–100	50
Milo	.60	85–95	100
Molasses	.46–.55	70	5
Oats	.48	88–94	25
Rye	.66	80–85	20
Wheat	.67	100–105	40
Wheat bran	.44	65–80	10
Wheat mids	.55	70–85	20

[a] Mcal = Mega calories = 1000 kilocalories = 1,000,000 calories.

it depresses gains. Thus, the basic decision regarding degree of processing is one of cost of processing versus improvement in feed utilization.

As a rule, the greater the degree of processing the greater the investment in a processing plant. The more sophisticated processing systems are adapted to large volume operations. One steam flaker can produce enough feed for about 5,000 cattle, and one man can take care of three or more flakers. Thus, flaking should be most competitive in lots where 15,000 or more cattle are on feed at one time.

Several new processing methods are being evaluated such as extruding, popping and micronizing. Some of these may produce results similar to flaking with lower investment costs and may be adapted to smaller feeding operations.

For the farmer-feeder who produces his own grain, high moisture grain storage appears a very competitive method of grain handling (Figure 3). Cost from harvesting to the feed bunk can be kept lower than any other handling method.

If high moisture grain is stored and fed properly, rate of gain is equal to that on other kinds of processed grain. Efficiency of feed conversion will be improved substantially for milo and slightly for corn compared to dry ground or rolled grain.

Storage of high moisture grain involves maintaining a large grain inventory for larger feedlots. In addition, buying and storing grain at uniform moisture levels will require careful management. The large feeder may want to take a careful look at reconstitution of grain. Reconstituted grain produces about the same results as grain harvested and stored as high moisture grain.

Feeding whole shelled corn has, in recent trials, produced results equal to ground or rolled corn. If these results continue the smaller feeder and the farmer-feeder will be in a more competitive position since feed processing is usually more expensive in smaller operations.

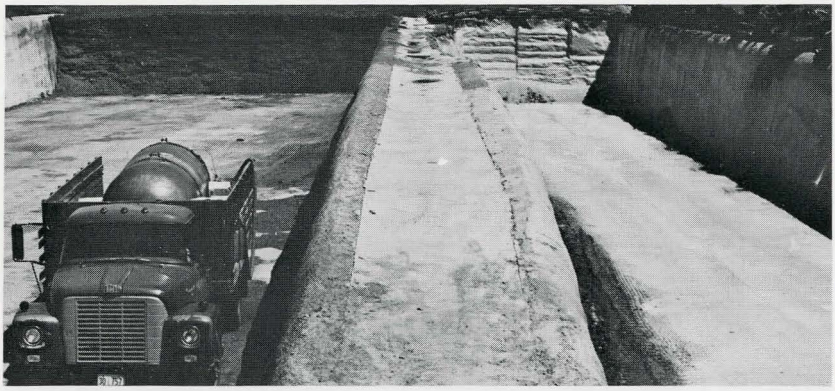

Figure 3. High moisture grain storage is a competitive method of grain handling for many farmer feeders.

Roughages

Roughages are included in finishing rations to provide nutrients and to contribute a physical nature of the ration that tends to reduce digestive disturbances and management problems.

In recent years, roughage has been less competitive as a source of energy because grain is cheaper and the cost of handling and processing roughage is higher. We now include roughage in the finishing ration first for its physical nature and second for its nutrient content. Therefore, roughage should be included in most finishing rations at the level needed to keep digestive disturbances and feeding problems at a minimum (Figure 4).

Many kinds of roughage have been shown to meet the physical needs of the ration. Alfalfa hay, silages, corn cobs, straw, hulls from various crops and many other kinds of roughage have been effective in contributing to the physical needs of the ration.

Roughages vary considerably in their nutrient composition. Alfalfa will be more valuable than most roughages because it provides more protein. Corn silage is valuable mainly because of its energy content.

Figure 4. Roughage is processed primarily to facilitate handling and mixing in the ration.

Allowance for these differences should be made when purchasing roughages.

Roughage Processing—The primary objective in processing roughage is to change it to a form that can be handled mechanically, and can be consumed without waste.

Once these objectives have been met, finer processing of a roughage will reduce its effectiveness in contributing desirable physical properties to the ration and will increase the processing cost.

Hay should be fed coarsely chopped. Corn cobs should be ground through a ¼″ screen. Silage should be cut at approximately a ⅜″ setting or if harvested at less than 60% moisture, should be run through a recutter screen.

Roughage Levels in Finishing Rations—The optimum roughage level in final finishing rations appears to be about 5 to 10% of the total dry matter of the ration when it is uniformly mixed. This is equivalent to about 1 to 2 pounds of dry matter from roughage each day.

Where facilities are not available for uniform mixing, roughage levels of 15 to 20% (3 to 4 pounds of dry matter per day) will often result in fewer digestive disturbances and faster rate of gain than the lower levels.

Where cattle are fed with hired or inexperienced labor, formulation of a series of rations designed to get the cattle started on feed with a minimum of trouble is often more satisfactory than adjusting the grain-roughage ratio from day to day according to the "eye of the master."

We suggest four rations, each to be fed a minimum of three and a maximum of five days except when the cattle show indications of digestive disturbances. Suggested roughage levels are shown in Table 2. As many as 6 to 8 rations may be used in the transition to full feed. When more rations are used changes should be made fast enough to get them on full feed in approximately the end of the third week in the lot.

The 60–70% roughage level suggested for Ration No. 1 is suitable for full feeding to green cattle at the start providing they have a chance to fill on hay their first day in the lot. After that, no additional loose hay should be needed. Where cattle may be accumulated over a period of several days a grower ration containing somewhat more roughage may be an appropriate additional ration.

After about five days, cattle should be changed to Ration No. 2. This change can be made abruptly or it can be made more slowly by feeding Ration 2 in the morning and Ration 1 in the evening for a couple of days. The change from Ration 2 to 3 and from Ration 3 to 4 can be made in a similar manner when cattle seem to be "slow starters."

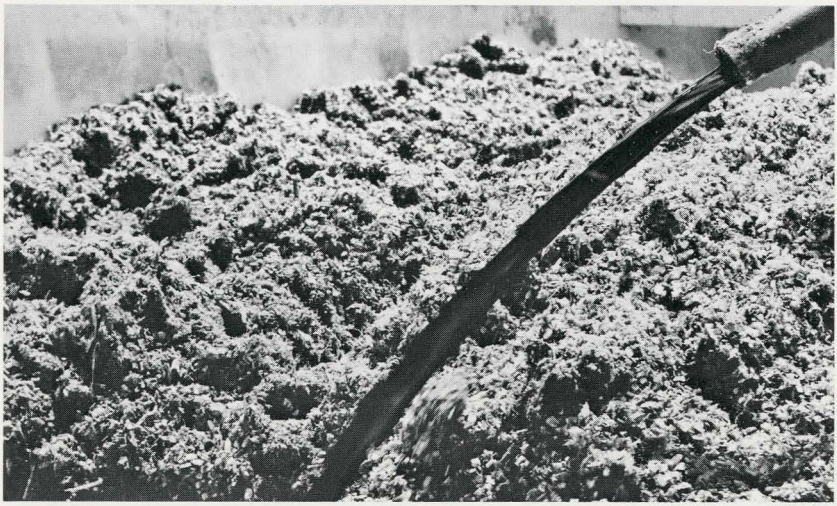

Figure 5. Liquid supplements control dustiness in the ration as well as add nutrients.

Supplements

Plant proteins and/or non-protein nitrogens can be used to provide the supplemental protein equivalent in the final finishing ration. Plant proteins appear to be more efficient in the starting phase than non-protein nitrogen. Rations containing non-protein nitrogen should be mixed uniformly and kept before the cattle at all times.

Use of urea and other non-protein nitrogen compounds can often reduce the cost of gain by 50¢ to $1 per cwt. When the energy content of a supplement containing urea is equal to a plant based supplement, the saving is almost proportional to the difference in cost of the supplement.

Many supplements containing urea, however, are formulated with less energy per unit of protein than plant based supplements. When this is the case, a direct comparison cannot be made because grain will have to be fed to compensate for the lower energy per unit of protein in the supplement.

High urea dry supplements or liquid supplements appear to be satisfactory in finishing rations if each is properly formulated (Figure 5). Dry supplements may absorb moisture and bridge in the bin if they contain more than 10% urea (28% protein equivalent from urea).

In some rations urea in meal type supplements may "separate out" as feed is unloaded into storage or into the bunk. Feeding silage or molasses should reduce this problem. Some liquid supplements may separate or segregate during storage. Because of this, storage tanks should be equipped for remixing or recirculation.

Calcium fortification of the ration containing liquid supplements should receive special attention since many liquid supplements do not contain appreciable calcium.

Separate supplements or premixes can be used for protein, minerals, vitamins and some of the feed additives but most feedlots do not have the labor and equipment to handle the variety of premixes needed for proper supplementation.

Many feed companies will manufacture, on a competitive bid, a supplement designed for your ration needs. Feed manufacturers can usually produce supplemental feeds cheaper than the feedlot operator because their equipment is used more fully and their personnel are trained in the specialized phases of feed manufacturing.

Even though manufacturing your own supplement may not be practical or economical, you will be equipped to choose supplements more intelligently if you understand some of the basics of supplement formulation. Many of the points to consider in formulating supplements are discussed in the section on formulation of supplements.

NUTRIENT SPECIFICATIONS

Nutrient specifications (on a dry matter basis) along with roughage levels are shown in Table 2.

Energy—For the usual rations fed in Nebraska, the roughage level will control adequately the energy content of the ration. However, for

Table 2. Specification for finishing rations.[a]

	Ration No. 1		Ration No. 2		Ration No. 3		Ration No. 4	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Roughage (%)	60	70	30	35	15	20	5	10
Net energy for gain megcal/100 lbs.	33	...	44	...	58	...	61	...
Crude protein (%)	11.5	...	11.5	...	11.5	...	12.0	...
Urea (%)	...	0	...	0	...	1.0	...	1.0
Calcium (%)	.35	.9	.35	.8	.35	.5	.35	.5
Phosphorus (%)	.35	.5	.35	.5	.35	.5	.35	.5
Salt (%)	.3	.3	.3	.3	.3	.3	.3	.3
Potassium (%)	.55	...	.55	...	.55	...	.55	...
Iodine[b] mg./lb.	.1	...	.1	...	.1	...	.1	...
Cobalt[b] mg./lb.	.05	...	.05	...	.05	...	.05	...
Copper[b] mg./lb.	4.0	...	4.0	...	4.0	...	4.0	...
Zinc[b] mg./lb.	25.2	...	25.2	...	25.2	...	25.2	...
Vitamin A IU/lb.	1400	...	1400	...	1400	...	1400	...
Stilbestrol[c] mg./lb.	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Antibiotic[d] mg./lb.	?		?	?	?	?	?	?

[a] On a dry matter basis (moisture free).

[b] 1 mg. iodine, 1 mg. cobalt, 15 mg. copper and 100 mg. zinc per head daily added in the supplement.

[c] .55 mg./lb. for cattle under 750 lb. or if antibiotic is fed, may feed heifers MGA in lieu of stilbestrol.

[d] Follow FDA regulations and manufacturer's recommendations.

computer formulation of least cost rations, establishing a requirement for a minimum amount of net energy for gain (NE) helps to eliminate the use of cheap but low energy ingredients which may be selected for filler.

Protein—We recommend 12% crude protein for Ration No. 4 and 11.5% crude protein for the other rations. We suggest the use of crude rather than digestible protein in formulating rations because:

1. Digestible protein is not published for some ingredients.

2. If analyses of the feeds fed are used, digestible protein must be estimated.

The levels suggested are somewhat higher than the requirement listed by the National Research Council and allow some protection from feedstuffs of lower than average protein content and digestibility.

All supplemental protein equivalent needs can be met by urea in Rations 3 and 4 where as much as 1% urea can be used if needed. Recent data indicate that cattle gain more rapidly and efficiently if plant protein supplements are used in the starting rations.

Minerals—A minimum of .35% calcium and .35% phosphorus is suggested for all rations. This should be somewhat higher than is actually needed. Thus, it offers a margin for safety should the feedstuffs used be below average in calcium or phosphorus. When finishing rations contain more than .6% calcium, rate of gain may be lowered. However, high levels of calcium from legume roughages do not appear to depress gain in growing rations. Maximums on calcium are included in the specifications to reduce the use of ground limestone as a filler in least cost computer formulated rations.

Where rations are uniformly mixed and separation of ingredients is not a problem, salt should be force fed at the rate of .3% of the ration (dry matter). Potassium could be lower than estimated requirements (.55%) in Ration 4. A more careful evaluation of the potassium requirement is needed to make valid recommendations regarding potassium fortification.

Trace Minerals—Trace minerals apt to be deficient are cobalt, zinc and perhaps iodine. Copper may be deficient in some areas. Rather than calculate the ration content for these, we suggest adding the following levels of trace minerals to the daily supplement: 1 mg. cobalt, 1 mg. iodine, 15 mg. copper and 100 mg. zinc. If rations are formulated in the computer a more refined trace mineral fortification may be indicated.

Vitamin A—We suggest adding about 30,000 international units (IU) of synthetic stabilized vitamin A per head daily regardless of the carotene content of the ration.

Hormones—Stilbestrol should be included at the rate of 10 or 20 milligrams (mg.) per head daily or about .55 or 1.1 mg. per pound of dry matter for steers. The higher rate is approved only for cattle

weighing over 750 pounds when antibiotics are not fed. Either stilbestrol at this rate or MGA (Melangestrol Acetate) at .25 to .50 mg. per head daily should be included in heifer rations. Be sure to follow specified withdrawal regulations for each feed additive fed.

Antibiotics—If liver abscesses are a problem in your lot, an approved antibiotic should be fed. If liver abscesses are not a problem, then you may prefer to feed 20 mg. stilbestrol per head daily leaving antibiotics out of the regular feed.

Antibiotics should be included in starter rations at high levels (350 mg. or more) when sanitation is poor or the lot seems to be troubled with low level disease problems in starting cattle. Recent work with feeding 1 gram (gm.) antibiotic daily for a few days in the middle of the feeding period needs more evaluation before it can be routinely recommended.

FORMULATING FINISHING RATIONS

To calculate finishing rations you'll need to use:

1. The nutrient specifications in Table 2.
2. The ingredient restrictions in Table 1.
3. The composition of feeds in Table 10 or analyses of your own feedstuffs.
4. The approximate grain intake in Table 3.

In many cases, you'll be checking the ration after the cattle are on feed. This is rather simple since your main interest is to check for deficiencies and excesses.

When you calculate the ration for cattle yet to be placed on feed the procedure is more complex. The first step is to determine the kind and amount of roughage to be fed. Then you need to determine other feeds to be included at fixed levels, if any. Then, where the ration is formulated according to percentage of ingredients, you determine the amount of the primary grain and supplement needed to complete the ration. If the ration is formulated on the basis of daily consumption (fixed daily amount of roughage and supplement with grain fed according to appetite) you'll need to estimate the concentrate consumption before you can calculate the ration (Table 3).

Table 3. Estimated daily intake of concentrates for cattle on full feed.

Stage of feeding period	Concentrate intake per 100 lbs. live weight (dry matter lbs.)	
	Average for calculating	Expected range
First month	2.3	2.1 — 2.4
Second month	2.1	1.9 — 2.2
Third month	2.0	1.8 — 2.1
Fourth month	1.9	1.7 — 2.0

Table 4. Checking nutrient balance of a ration being fed to 800 lb. steers.

Kind of feed fed	Quantity as fed	Quantity of dry matter fed	Nutrient content		
			Protein	Calcium	Phos.
	(lbs.)	(lbs.)	(lbs.)	(lbs.)	(lbs.)
1. Alfalfa haylage (55% H_2O)	4.5	2.0	.36[a]	.027[a]	.005[a]
2. Corn (18% H_2O)	21.5	17.6	1.76[a]	.004[a]	.053[a]
3. Supplement[b]	1.0	.9	.40	.020	.015
4. Nutrients fed	...	20.5	2.52	.051	.073
5. Nutrients required[c]	...	...	2.56	.072	.072
6. Nutrient deficiency or excesses	...	...	+.04	–.021	+.001

[a] Values obtained by multiplying nutrient composition (Table 10) by pounds dry matter fed daily.
[b] Guaranteed 40% protein, 2% calcium, 1.5% phosphorus. Salt should be added separately at the rate of .06 pound per head daily.
[c] Requirements for Finisher No. 4–(Table 2) times quantity of dry matter fed.

Calculating a Ration Being Fed on a Per Head Per Day Basis

The method to check the nutrient balance of a ration being fed on a per head per day basis is shown in Table 4. For this example we assume that the moisture content of the haylage and corn are 55% and 18% respectively. Also we assume that the protein, calcium and phosphorus content are not known and that average analyses are being used for calculation (Table 10). In balancing the ration we will plan on adding vitamin A and feed additives in proper amounts in the supplement.

To obtain the quantity of dry matter for each feed fed, multiply the percentage of dry matter by the pounds fed daily. Assume that dry supplements contain 90% dry matter and liquid supplements 65% dry matter.

In calculating nutrient content, multiply the pounds of dry matter from corn and haylage fed by the average or known composition of the feed. For commercial supplements, multiply the pounds as fed by the guaranteed composition which in this case is 40% protein, 2% calcium and 1.5% phosphorus. The nutrient composition for the total ration is shown on Line 4.

The nutrients required (Line 5) are calculated by multiplying the percentage requirements (Table 2) times the amount of dry matter fed. The nutrient excess or deficiency is determined by subtracting Line 4 from Line 5.

In this example the ration is about right in protein and phosphorus and deficient in calcium. It can be corrected by adding 6 pounds of ground limestone to the ration per 100 head of cattle (.021 x 100 ÷ .38) or by selecting a protein supplement containing 4.1% calcium instead of the 2% calcium as used in this example. The excess of protein and phosphorus is not enough to justify selection of another supplement.

Planning a Ration on a Per Head Per Day Basis

In most situations you'll want to plan your ration before the cattle are on full feed. This will help you select the proper supplement to give the nutrient balance needed.

Let's figure a ration containing 5 pounds of corn silage (70% H_2O) and 1 pound of supplement with corn (20% H_2O) full fed to steers weighing 800 pounds. The cattle can be expected to eat about 2.3 pounds of dry matter from concentrates per hundred pounds live weight (Table 3) when they get on full feed or about 18.4 pounds of dry matter from corn and supplement. This daily feed consumption was estimated as follows:

$$\frac{\text{Pounds Live Weight}}{100} \times \text{Estimated Concentrate Consumption (Table 3)}$$

The nutrients supplied by the silage and corn and the additional nutrients needed in the 1 pound of supplement are shown in Table 5.

Determine the nutrient content of the ration by multiplying the pounds of dry matter fed times the average or known composition of the feed stuff (Table 10). In this case we'll solve for the composition needed in the supplement to be fed. The nutrients required (Line 5) are determined by multiplying the dry matter fed (Line 4) times the nutrient requirements (Table 2). Subtract the nutrients supplied by corn and corn silage (Line 4) from the requirement (Line 5) to get the needed nutrient composition of the supplement (Line 6). In this example the supplement should contain about 52% protein, 6.1% calcium and 1.5% phosphorus (on an as-fed basis).

The quantity fed on an as-fed basis is determined by dividing the dry matter fed by the dry matter content for each ingredient in the

Table 5. Calculating a ration for 800 lb. steers to be fed a fixed level of silage and supplement daily and corn according to appetite.

Kind of feed	Quantity of dry matter fed	Nutrient content			Quantity as fed[a]
		Protein	Calcium	Phosphorus	
	(lbs.)	(lbs.)	(lbs.)	(lbs.)	(lbs.)
1. Corn silage (70% H_2O)	1.5	.12	.005	.003	5
2. Corn (20% H_2O)	17.5	1.75	.004	.052	21.9
3. Supplement	.9	...	...	...	1.0
4. Total	19.9	1.87	.009	.055	27.9
5. Nutrients required[b]	...	2.39	.070	.070	...
6. Nutrients needed in supplement[c]	...	.52	.061	.015	...

[a] Quantity of dry matter fed divided by dry matter content of feed fed.

[b] Requirements for Finisher No. 4 (Table 2) times quantity of dry matter fed.

[c] Supplement composition needed 52% protein, 6.1% calcium, 1.5% phosphorus. Salt should be added to the ration at the rate of .06 pound per head daily.

ration. Watch out or you will divide by the moisture content and have the wrong amount.

When the ration is actually fed you will often find that the cattle consume somewhat more or less than you've estimated. When this varies by as much as 10% from your estimate check the ration to see if the supplement needs to be adjusted.

A supplement of known nutrient content could have been included at the recommended feeding rate in the above example. Then the comparison of the nutrients required with the nutrients supplied would show either the nutrient deficiencies or the nutrient excesses of the ration as shown in Table 4.

Planning a Ration on a Percentage Basis

An example of calculating rations on the basis of percentage of ingredients is shown in Table 6. The ration is balanced for 800 lb. steers on their final finishing ration. We have selected 7.5% corn silage as the level and source of roughage.

The nutrients supplied by salt and corn silage per 100 pounds of dry matter fed are shown in Lines 1 and 2 (Table 6). Nutrients needed to balance the ration are shown in Line 3 and the nutrients needed in the corn and supplement used to complete the ration (Line 3—minus 1 and 2) are shown in Line 4.

The Pierson Square technique (Table 7) can be used to calculate the percentage of corn and supplement needed to complete the ration.

As shown in Line 4, 92.2 pounds of corn and supplement mixture should supply 11.39 pounds protein, .325 pounds calcium and .333

Table 6. Calculating a ration for 800 lb. steers where the ration is formulated on the basis of percentage of ingredients.

Kind of feed	Quantity of dry matter	Nutrient content			Quantity as fed	Percent as fed
		Protein	Calcium	Phosphorus		
	(lbs.)	(lbs.)	(lbs.)	(lbs.)	(lbs.)	(%)
1. Salt	.3	...	...	...	.3	.2
2. Corn silage	7.5	.61	.025	.017	25.0	19.0
3. Nutrients required (cwt/mix)	100.0	12.00	.350	.350	...	...
4. Nutrients short (cwt/mix)	92.2	11.39	.325	.333	...	...
5. Corn (13.5 H_2O)[a]	87.8	8.52	.018	.263	101.5	77.1
6. 60% pro supplement[a]	4.4	2.93	...	...	4.9	3.7
7. Mineral needed in supplement[b]	...	...	.307	.070	...	...
8. Total	100	12.06	.350	.350	131.7	100

[a] Determined by Pierson Square Technique using average protein needed in the corn-supplement (Line 4 [11.39 ÷ 92.2 = 12.4]), 9.7% protein corn, 60% protein supplement (66.7% protein dry basis).

[b] Supplement should contain approximately 60% protein, 6.3% calcium and 1.4% phosphorus.

Table 7. Using the Pierson Square to determine the percentage of corn and protein supplement needed to balance the ration in Table 6.

Protein in corn % 9.7 (dry basis)	% Protein Needed in Corn-Urea mix 11.39 ÷ 92.2 = 12.4	Ratio of corn needed 54.3
Protein in supplement % 66.7 (dry basis)		Ratio of supplement needed 2.7
		57.0 Total

Corn needed in ration (lbs./cwt)

$$\frac{54.3}{57.0} \times 92.2 = 87.8$$

Supplement needed in ration (lbs./cwt)

$$\frac{2.7}{57} \times 92.2 = 4.4 \text{ pounds}$$

pounds phosphorus. We will assume that we are going to use a 60% protein (66.7% protein on a dry matter basis) dry supplement in the ration and 13.5% moisture corn which contains 9.7% protein per pound of dry matter.

Determine the protein content needed in the corn supplement mixture by dividing protein needed by pounds of mix to complete the ration (11.39/92.2 = 12.4). Place the percent protein in corn at the upper left and the percent protein in the supplement at the lower left, and the percent protein needed in the mix in the center of the Pierson square as in Table 7. Then subtract the smaller from the larger diagonally.

For example, 12.4 − 9.7 equals 2.7 placed at the lower right of the square and 66.7 − 12.4 equals 54.3 placed at the upper right of the square. These figures represent the ratio of corn (54.3) to supplement (2.7) needed to produce a mixture containing 12.4% protein. Now convert these to pounds of corn and supplement needed in the ration by dividing each ratio by 57 (54.3 + 2.7) and then multiplying by the total pounds needed to complete the mix (92.2).

In the 4.4 pounds of dry matter in the supplement (4.9 pounds of air dry supplement) we need to supply .307 and .068 pounds of calcium and phosphorus respectively. The calculated composition of the supplement should be 60% protein, 6.6% calcium (.307 ÷ 4.9 × 100) and 1.4% phosphorus (.070 ÷ 4.9 × 100).

Now we need to determine the amount of each ingredient needed per 100 pounds of mix on an as-fed basis (Table 8). First we need to convert dry matter for each ingredient to an as-fed amount. Then we total these and divide this total into the quantity as-fed for each ingredient to get the percentage of each ingredient needed as-fed.

Table 8. Converting from a dry matter formula to an "as-fed" formula.

Kind of feed	Quantity of DM		Dry matter content		Quantity As-fed		Total As-fed		Percent As-fed
	(lbs.)		(lbs.)		(lbs.)		(lbs.)		
Salt	.3	÷	1.00	=	.3	÷	131.7	=	.2
Corn silage	7.5	÷	.30	=	25.0	÷	131.7	=	19.0
Corn	87.8	÷	.865	=	101.5	÷	131.7	=	77.1
Protein supplement	4.4	÷	.90	=	4.9	÷	131.7	=	3.7
Total	100		...		131.7		...		100.0

A ration chart showing the relative amounts of each ingredient needed will contribute to ease and accuracy of feeding when using this method. A chart is shown in Table 9 for 200 head fed twice daily. The amount of supplement, salt and corn needed are shown in parenthesis.

In most farm feedlots silage will be loaded first and dumped in with a tractor loader. Most of the time the amount dumped will be somewhat more or less than estimated needs. The weight (to the nearest 10 pounds) can be taken and the total amount of the ration fed determined on the basis of the silage loaded. Care should be taken to assure that the correct amount of supplement is added. Since a relatively small amount is used, any weighing error can change the ration composition substantially. Salt should be weighed on a small scale and dumped in the feed wagon. In this case we've allowed for its addition just ahead of the corn.

As an example let's assume that 2200 pounds was the estimated amount of feed needed. This would require 420 pounds of silage. In dumping the silage into the feed wagon you get 20 pounds more than needed.

Rather than adjust the other ingredients to make a 2200-pound total, you should add amounts corresponding to 440 pounds of silage which will make 2300 pounds of total feed.

NUTRITIONAL DISTURBANCES

Nutritional imbalances may cause, or be implicated in, feedlot problems. Some suggestions in regard to those most frequently involved are:

Bloat

Most bloat can be overcome by one or more of the following:
Crack grain more coarsely.
Mix grain and roughage uniformly.
Raise roughage level temporarily.
Feed lower quality roughage.
Substitute corn for other grains.
Be sure water supply is adequate.

Table 9. Ration formulation sheet.

Ration Ingredients

Total mix	Corn silage 19% *Amount and scale reading*	Supplement 3.7%		Salt .2%	Corn 77.1%	
		Amount[b] required	*Scale reading*	Amount[a] required	Amount[b] required	*Scale reading*
(lbs.)	(lbs.)	(lbs.)	(lbs.)	(lbs.)	(lbs.)	(lbs.)
1500	285	(55)	340	(3)	(1157)	1500
1550	295	(55)	350	(3)	(1197)	1550
1600	305	(60)	365	(3)	(1232)	1600
1650	315	(60)	375	(3)	(1272)	1650
1700	325	(65)	390	(3)	(1311)	1700
1750	335	(65)	400	(4)	(1346)	1750
1800	340	(65)	405	(4)	(1391)	1800
1850	350	(70)	420	(4)	(1430)	1850
1900	360	(70)	430	(4)	(1466)	1900
1950	370	(70)	440	(4)	(1506)	1950
2000	380	(75)	455	(4)	(1541)	2000
2050	390	(75)	465	(4)	(1576)	2050
2100	400	(80)	480	(4)	(1616)	2100
2150	410	(80)	490	(4)	(1656)	2150
2200	420	(80)	500	(4)	(1696)	2200
2250	430	(85)	515	(4)	(1731)	2250
2300	440	(85)	525	(5)	(1770)	2300
2350	445	(85)	530	(5)	(1806)	2350
2400	455	(90)	545	(5)	(1850)	2400
2450	465	(90)	555	(5)	(1890)	2450
2500	475	(90)	565	(5)	(1930)	2500
2550	485	(95)	580	(5)	(1965)	2550
2600	495	(95)	590	(5)	(2005)	2600
2650	505	(100)	605	(5)	(2040)	2650
2700	515	(100)	615	(5)	(2080)	2700
2750	525	(100)	625	(6)	(2121)	2750
2800	530	(105)	635	(6)	(2159)	2800
2850	540	(105)	645	(6)	(2199)	2850
2900	550	(105)	655	(6)	(2239)	2900
2950	560	(110)	670	(6)	(2274)	2950
3000	570	(110)	680	(6)	(2314)	3000

[a] Weighed daily on small scale.
[b] Can be left off sheet used in mill.

Acidosis and Associated Digestive Disorders

When cattle eat too much grain during a short period of time a number of digestive disorders can occur including *enterotoxemia, founder* and *diarrhea*. These are some of the results of an acidosis syndrome that frequently occurs in cattle feeding. Although these may occur when cattle are fed relatively liberal amounts of roughage, they occur much more frequently among cattle fed high concentrate or all concentrate rations.

Table 10. Average composition of common feeds.

Feedstuff	Avg. dry matter	On a dry basis (moisture free)							
		Crude protein	Energy			Calcium	Phosphorus	Fiber	Carotene
			TDN	NE_M	NE_G				
	%	%	%	Mcal./lb.		%	%	%	mg./lb.
Concentrates									
Barley	90	12.8	87	.97	.64	.07	.40	8	...
Beet pulp	91	9.8	72	.73	.60	.76	.11	23	...
Beet pulp w/molasses	91	9.9	74	.92	.61	.62	.09	18	...
Beet pulp w/LPC	91	17.7	72	...	.60	.76	.11	20	...
Brewers dried grains	92	30.6	66	1.09	.48	.30	.56	18	...
Corn, dent, grade No. 2	86	10.0	91	1.04	.67	.02	.30	2	...
Corn-and-cob meal	87	8.2	81	1.01	.60	.04	.24	11	...
Distillers dried grains (corn)	92	29.6	93	.90	.60	.10	.41	14	...
Fat, animal	100	...	...	2.08	1.41	...	...	...	...
Hominy feed	91	11.1	95	1.11	.68	.06	.22	7	...
Millet	90	13.3	82	1.00	.65	.06	.31	9	...
Molasses:									
Cane	75	4.0	95	1.03	.55	.67	.07	...	...
Beet	77	8.7	89	.93	.46	.21	.04	...	...
Corn sugar	78	.4	...	...	.48	.59	.06	...	...
Oats	89	13.3	66	.79	.57	.11	.37	13	...
Oat mill by-product	92	4.5	25	...	...	.20	.22	35	...
Rye	89	14.0	86	.99	.66	.11	.37	3	...
Sorghum milo	89	10.0	89	.95	.60	.02	.30	3	...
Soybean mill feed	91	14.4	45	.45	.03	.39	.17	36	...
Wheat	90	14.7	92	1.04	.67	.06	.44	3	...
Wheat bran	89	17.8	70	.70	.44	.14	1.43	11	...
Wheat middlings	89	19.1	83	.89	.55	.09	1.0	9	...
Wheat screenings	90	14.2	72	.98	.55	.48	.43	10	...
High Protein Concentrates									
Cottonseed meal									
Expeller	94	43.6	78	.82	.55	.17	1.28	13	...
Solvent	91	46.2	70	.77	.46	.17	1.11	14	...
Linseed meal									
Expeller	91	35.3	81	.86	.58	.48	.98	9	...
Solvent	91	37.8	78	.79	.54	.39	.83	10	...
Meat and bone meal	94	55.6	74	.73	.47	11.11	5.56	2	...
Safflower seed meal	92	24.4	64	.90	.46	.28	.79	34	...
Soybeans	90	41.7	94	1.10	.70	.28	.64	6	...
Soybean oil meal									
Expeller	90	46.7	86	.94	.62	.22	.67	7	...
Solvent	89	48.9	81	.88	.58	.28	.67	7	...
Tankage	92	66.7	79	...	...	6.67	3.49	2	...
Dry Roughages									
Alfalfa-grass hay	90	13.3	54	.62	.20	1.31	.27	34	7
Alfalfa hay									
Early bloom	90	19.4	58	.55	.22	1.56	.28	28	22
Mid-bloom	90	16.0	55	.56	.18	1.50	.23	31	9
Full bloom	90	15.5	53	.47	.09	1.26	.20	33	4
Dehy. alfalfa pellets									
20% protein	93	22.2	64	.62	.36	1.67	.30	22	104
17% protein	93	18.9	62	.60	.27	1.43	.35	27	69
15% protein	93	16.3	61	.60	.21	1.32	.24	28	50
Blue grama, range cured	90	4.1	47	...	...	.21	.08	34	...

Table 10. Average composition of common feeds (continued).

Feedstuff	Avg. dry matter	On a dry basis (moisture free)							
		Crude protein	Energy			Calcium	Phosphorus	Fiber	Carotene
			TDN	NEM	NEG				
	%	%	%	Mcal./lb.		%	%	%	mg./lb.
Bluestem, range cured	90	2.9	47	...	...	.29	.07	34	...
Bromegrass hay									
Before bloom	90	16.7	54	.64	.22	.65	.36	29	33
In bloom	90	10.0	52	.60	.18	.43	.18	35	...
Mature	90	6.3	46	.60	.14	.31	.14	36	...
Corn cobs	90	2.8	47	.48	.14	.12	.04	36	...
Corn stover	87	5.6	59	.55	.14	.42	.08	30	...
Cottonseed hulls	90	4.3	41	.47	.10	.16	.10	48	...
Prairie hay									
Early cut	90	8.7	60	.60	.27	.57	.19	32	22
Average	90	6.2	51	.60	.18	.51	.08	32	10
Mature	90	4.7	48	.60	.14	.39	.09	35	10
Red clover hay avg.	90	14.6	54	.57	.24	1.57	.21	29	8
Sorghum fodder	85	7.9	58	.56	.26	.40	.17	26	7
Sorghum stover	85	5.3	46	.55	.12	.40	.11	33	7
Western wheat grass hay	90	7.3	56	.60	.22	.30	.15	38	...
Wheat straw	90	3.6	48	.47	.09	.17	.08	42	2
Silages									
Alfalfa									
Direct cut early bloom	25	17.8	54	.60	.27	1.37	.24	32	61
Wilted early bloom	40	17.8	55	.60	.27	1.41	.24	32	32
Beet top									
Much dirt adhering	32	11.9	47	.52	.19	.97	.22	12	12
Corn, dent	30	8.1	69	.70	.38	.33	.23	24	...
Sorghum silage	29	7.3	57	.57	.30	.25	.18	26	...
Sorghum, sweet	25	6.4	61	.60	.30	.32	.20	36	...

Mineral Concentrates

Feedstuff	Avg. dry matter	On a dry basis			On an as-fed basis		
		Crude protein	Calcium	Phosphorus	Crude protein	Calcium	Phosphorus
	%	%	%	%	%	%	%
Bone meal steamed	95	...	30.5	14.3	...	30.0	13.6
Limestone	100	...	38.0	...	...	38.0	...
Phosphate, ammonium poly (liquid)	60	104.0	...	24.8	62.5	...	14.9
Phosphate defluorinated rock	100	...	32.0	18.0	...	32.0	18.0
Phosphate diammonium	85	132.0	...	25.5	112.5	...	20.0
Phosphate dicalcium	96	...	23.1	18.6	...	22.2	17.9
Phosphate monocalcium	100	...	20.0	21.0	...	20.0	21.0
Phosphate monosodium	97	...	...	22.5	...	...	21.8
Phosphate sodium tripoly	96	...	...	26.0	...	...	24.9
Phosphoric acid	75	...	...	31.6	...	...	24.0

Restricted intake followed by a high grain intake over a short period of time is the usual cause of these disturbances. The restriction in intake and subsequent overfeeding may be the result of:

1. Failure to keep feed before the cattle at all times.
2. Changes in weather conditions.
3. Changes in palatability of feeds fed.

If relatively few animals are affected it can usually be corrected by feeding regularly, keeping feed before the cattle at all times, mixing the feed uniformly and avoiding abrupt ration changes. Where the problem is acute, increasing the roughage content of the ration for a short time to 20, 35 or perhaps 50% of the ration may be the most effective way to get the cattle back on feed quickly.

Liver Abscesses

Liver abscesses are more numerous among cattle fed high concentrate finishing rations. Early work in Nebraska also indicates that the calf environment may influence occurrence of liver abscesses. The exact cause is not known. Abscesses may be associated with digestive disturbances that are either unnoticed or considered of little consequence. Occasionally, however, cattle fed high or all concentrate rations have a low incidence.

Liver abscesses can be reduced by low level feeding of an antibiotic approved for this use. Careful management of the feeding program, especially when starting cattle on feed, may also be helpful.

Nitrate Toxicity

Nitrate toxicity should not be a problem in finishing cattle except on the early starting ration. Grains are low in nitrate and full feeding spreads out the intake of any nitrate included in the ration. Cattle seem to adjust to nitrate if started on high nitrate feeds carefully.

Nitrate levels in water are normally below the levels necessary for a nitrate toxicity to occur once the cattle are on a finishing ration.

Where nitrate toxicity is involved in starting cattle, substitute enough low nitrate feeds for the high nitrate containing feeds to reduce the nitrate intake to a safe level. Mix the total ration together, feed a balanced ration and keep feed before the cattle at all times. Then after a short adjustment period the high nitrate feed can be increased gradually if necessary. On the other hand, if cattle are being started on grain at a reasonably rapid rate the roughage content of the ration after 7 to 10 days should be low enough that a high nitrate roughage could be used as the only roughage source.

The addition of vitamin A will not alleviate nitrate toxicity. It will correct a vitamin A deficiency if one exists.

Water Belly

Water belly is a rather infrequent problem in the feedlot. If more than usual water belly occurs:

Check to see that the ration contains at least .35% calcium.

Force feed salt at .5 to 1% of the ration, or feed ammonium chloride at the rate of 1 to 1.5 ounces per head per day until urinary calculi cease to occur.

Foot Rot

Generally, we do not think of foot rot as a nutritional problem. It is included in this section for two reasons:

1. Organic iodine is included in some feeds for the prevention of foot rot.

2. Some suspect that foot rot might be associated with rumenitis and perhaps other types of digestive disturbances.

Organic iodine may help prevent foot rot if fed continuously at 50 mg. per head daily or intermittently at 400 to 500 mg. daily for 2 to 3 weeks when evidence of an outbreak occurs. It won't completely eliminate foot rot. If fed too long at levels above 50 mg. per head daily, organic iodine will cause a hacky cough, excessive watering of the eyes and reduced feed intake.

In some instances, foot rot may be associated with digestive disturbances. In this case, management practices that contribute to a more uniform and adequate feed intake from day to day should help. Such things as weighing feeds accurately, mixing feeds uniformly, regular feeding, a plentiful water supply (Figures 6, 7), keeping cattle cool, etc., all should be helpful in reducing digestive disturbances.

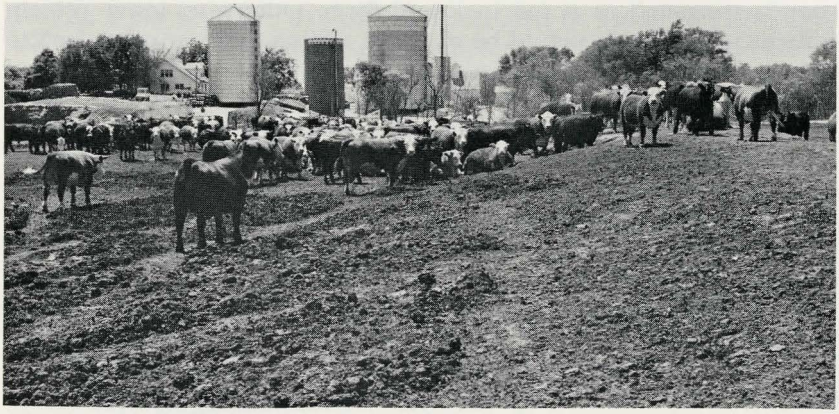

Figure 6. Well shaped mounds help keep cattle out of the mud—the number one enemy of rapid and efficient gains.

Figure 7. A clean fresh supply of water is an indication of top feedlot management.

FORMULATING SUPPLEMENTS

One of the first decisions that must be made in formulating supplements is to determine the approximate rate at which the supplement is to be fed. At least three factors have a role in this decision:

1. The amount of supplemental protein needed.
2. The percentage of protein to be supplied by urea.
3. The ability to uniformly mix the ration at the feedlot.

Where higher amounts of supplemental protein are needed, either more supplement must be fed or urea added to increase the protein equivalent above that contained in plant protein. Where urea is to supply most of the supplemental protein equivalent, high analysis supplements or premixes can be fed if good mixing equipment is used and the material either does not develop "bin set," is sacked to prevent "setting up" or is fed in liquid form. Otherwise, lower protein content supplements should be made by adding grain or other feed to reduce the percent of urea to a point where "bin set" is not a problem in dry supplements or where uniform mixing is not so critical.

For examples, we will develop 40% and 80% protein equivalent supplements to be fed in rations where 2 pounds of alfalfa hay are fed and 30 to 60% supplements to be fed where non-legume roughage is used. These supplements will all be fed to cattle weighing over 750 pounds. Rate of feeding and nutrient and additive composition are shown in Table 11.

Once the protein level and the rate of feeding have been fixed, then the calcium and phosphorus content of the supplement should be determined. All feed grains are very low in calcium and the calcium needed to balance the ration will be largely determined by the kind and amount of roughage fed and the rate at which the supplement is fed.

Table 11. Composition of supplements for two types of roughage and a poor and uniform ration mix.

Roughage fed	Alfalfa hay (2 lb. daily)		Non-Legume roughage	
Degree of ration mix	Poor	Uniform	Poor	Uniform
Supplement No.	1	2	3	4
Rate of feeding (lb./da)	1	.5	2	1
Protein (%)	40	80	30	60
Calcium (%)	3.5	7.0	3.0	6.0
Phosphorus (%)	1.5	2.5	1.0	1.5
Stilbestrol (mg./lb.)	10	20	5	10
Vitamin A (IU/lb.)	30,000	60,000	15,000	30,000
Cobalt (mg./lb.)	1	2	.5	1
Copper (mg./lb.)	15	30	7.5	15
Iodine (mg./lb.)	1	2	.5	1
Zinc (mg./lb.)	40	80	20	40
Antibiotic (mg./lb.)	70	140	35	70

By using an average feed intake the calcium level needed in the supplement can be calculated quickly. It may need to be as high as 7 to 10% in some of the higher protein supplements. The requirements for our example supplements vary from 3 to 7% calcium.

Because the phosphorus content of grains normally approaches the requirements of finishing cattle, supplements need to contain only enough phosphorus to insure against below-average phosphorus content of the feedstuffs used. Normally this need will be met if supplements to be fed at .5, 1 and 2 pounds per head daily are formulated to contain 2.5, 1.5 and 1% phosphorus, respectively.

Ration specifications for trace minerals, vitamin A and feed additives on a per head per day basis are included in Table 2. These have been adjusted for the rate that the supplement is to be fed and added to Table 11.

If the supplement is to be pelleted, addition of binding materials such as bentonite, lignin sulfonate, etc., may be needed. In addition, some feedstuffs that pellet well should be included in the formula. Dehydrated alfalfa, soybean meal and cottonseed meal are three feedstuffs that contribute to pellet firmness. Grains generally are hard to pellet and most roughages contribute little to making a firm pellet. About 2% animal fat will increase the rate of pelleting and reduce the cost of pelleting. Because of this, fat will often be included in pelleted feeds.

In formulating these supplements, we will plan to:

1. Meet the specifications in Table 11.
2. Use urea to provide as much of the protein equivalent as possible.

3. Pellet the supplement where possible.

4. Use corn as the "filler."

5. Use normal air dry feeds and average analysis on an air dry basis rather than a dry basis.

As we evaluate the protein content of the supplements we raise a question immediately in regard to pelleting and storing a 60% and an 80% high urea supplement since as much as 20 to 25% of the supplement may need to be urea. For this example we will not pellet the 80% supplement. We will plan to make it into a meal which will be delivered in paper sacks to prevent "setting up." We will pellet the 60% supplement by reducing the urea to about 10% (28% protein equivalent) and by adding additional soybean meal to provide the rest of the protein needed and to contribute to pellet firmness.

In putting the supplement together follow these steps:

1. Determine the amount of additive premixes needed. We will use a stilbestrol premix containing 2 gm. stilbestrol per pound and an antibiotic premix containing 50 gm. antibiotic per pound to provide 70 mg. per head daily. The amounts needed are shown in Table 12 (Lines 1a and 1b).

2. Next, add the vitamin A premix (30,000 IU/gm.) and a trace mineral premix designed to supply the approximate quantities of trace minerals needed (Lines 2a and 2b).

3. Add the pelleting aids—animal fat to increase rate of pelleting (Line 3a), a pellet binder (Line 3b), dehydrated alfalfa (Line 3c) and soybean meal (Line 3d) to increase the pellet firmness. Since Supplement 2 will not be pelleted we will not add any of these but rather include 6.0% molasses to reduce separation in the meal mixture (Line 4).

In Supplement 4, urea will provide nearly half of the protein equivalent (28%). Thus we'll need to add enough soybean meal and/or dehydrated alfalfa to provide about half the protein equivalent of the supplement. It will take about 1300 pounds soybean meal (Line 3d) to provide the plant protein needed [1200 pounds protein per ton ÷ 2 ÷ .457 (protein content of soybean meal)]. Because this is a high percentage of the total supplement and should contribute the "pelletability" needed, dehydrated alfalfa and a pellet binder will not be added to this supplement.

4. Estimate the major mineral needs—these will need a final adjustment to the proper level after the amounts of corn and urea needed have been determined. Phosphorus needs should be estimated first. In this case we will use a rough estimate of .3% phosphorus in the basic ingredients and we will use dicalcium phosphate containing 18.5% phosphorus as the phosphorus source. A rough estimate of dicalcium phosphate needs would be 75, 130 and 240 pounds respectively for supplements to be fed at 2, 1 and .5 pounds per head daily (Line 5a).

Table 12. Formulating supplements.[a]

Roughage	2 lbs. of alfalfa daily		Non-legume	
Degree of ration mix	Poor	Uniform	Poor	Uniform
Supplement No.	1	2	3	4
Protein content	40	80	30	60
1. Additives				
a. Stilbestrol premix—2 gm./lb. (lbs.)	10.0	20.0	5.0	10.0
b. Antibiotic premix—50 gm./lb. (lbs.)	2.8	5.6	1.4	2.8
2. Minor ingredients				
a. Vitamin A premix—30,000 IU/gm. (lbs.)	4.4	8.8	2.2	4.4
b. Trace mineral premix[b] (lbs.)	10.0	20.0	5.0	10.0
3. Pelleting aids				
a. Animal fat (lbs.)	40.0	...	40.0	40.0
b. Pellet binder[c] (lbs.)	40.0	...	40.0	...
c. Dehydrated alfalfa 17% protein (lbs.)	200.0	...	200.0	...
d. Soybean oil meal solvent (lbs.)	200.0	...	200.0	1300.0
4. Separation preventive-molasses (lbs.)	...	120.0	...	...
5. Major minerals				
a. Dicalcium phosphate (est. lbs.)	135.0	240.0	75.0	130.0
b. Ground limestone (est. lbs.)	100.0	225.0	105.0	245.0
6. a. Total of required ingredients (lbs.)	742.2	639.4	673.6	1742.2
b. Protein in required ingredients (lbs.)	126.4	3.6	126.4	594.1
7. Calculation of corn-urea needed				
a. Corn-urea needed/T (lbs.)	1257.8	1360.6	1326.4	257.8
b. Protein needed in corn-urea mix (lbs.)	673.6	1596.4	473.6	605.9
c. Protein in corn-urea mix (%)	53.6	117.3	35.7	235.0
8. a. Corn needed in corn-urea mix[d] (%)	83.5	60.1	90.1	16.9
b. Urea needed in corn-urea mix[d] (%)	16.5	39.9	9.9	83.1
c. Corn needed per ton supplement (lbs.)	1050.4	817.7	1195.1	43.6
d. Urea needed per ton supplement (lbs.)	207.4	542.9	131.3	214.2
9. Calculated composition of rough mix				
a. Protein (%)	40.0	80.0	30.0	60.0
b. Calcium (%)	3.6	7.0	3.0	6.0
c. Phosphorus (%)	1.5	2.3	.9	1.6

[a] Formulated on "as-fed" rather than "dry matter" basis.
[b] Premix designed to supply trace minerals shown in Table 2.
[c] One of the commercial products available.
[d] Determined by Pierson square technique (Table 13).

To estimate the ground limestone needed, calculate the calcium supplied by the dicalcium phosphate, the dehydrated alfalfa and soybean meal. Subtract this figure from the amount needed per ton based on requirements in Table 11 and divide this by .38, the amount of calcium per pound of ground limestone (Line 5b).

Salt could be added to the supplement to provide .3% of the ration. However, since this is not a common practice in the industry, we will not include it in these examples.

5. Determine the combination of corn and urea which will supply the protein needed to complete the ton of supplement. To do this calculate the total weight of the required ingredients (Line 6a, Table 12) and the amount of protein supplied by the dehydrated alfalfa and soybean meal (Line 6b). A small amount of protein will be included in some of the premixes used but not enough to bother to calculate their contribution to the protein content. Then determine the total pounds of corn and urea needed to complete the ton of supplement, the pounds of protein needed to bring the protein up to the desired level and the percentage protein needed in the mix (Line 7a, b and c). Now calculate the percentage of corn and urea needed by use of the Pierson Square technique. This method is shown in Table 13.

The percentages of corn and urea needed in the mix to complete the ton of supplement are shown in Lines 8a and b, of Table 12. The amount of corn and urea needed to complete the rough formulation of the supplement can be obtained by multiplying Line 7a times 8a and 8b to give the amounts shown in 8c and 8d.

6. Next check the calculated composition of the rough formulation (Line 9a, b and c) with the planned composition. Then estimate the modifications needed. Supplement 1 is slightly under on phosphorus and over on calcium. This can be corrected by adding 5 pounds of dicalcium phosphate and reducing the ground limestone by 5 pounds. Supplement 2 is short in phosphorus. This can be corrected by substituting 20 pounds of dicalcium phosphate for 10 pounds of ground limestone and 10 pounds of corn. Supplement 3 is also a bit short of phosphorus. In this case adding 10 pounds of dicalcium phosphate in place of 10 pounds of corn will correct the deficiency. Supplement 4 is high in phosphorus. In this case adding 10 pounds of ground limestone in place of 10 pounds dicalcium phosphate should correct the formulation.

Table 13. Use of the Pierson Square to determine percentage of corn and urea to add to complete supplement 1.

Protein in corn (% as fed)	8.7	% Protein Needed in Corn-Urea Mix **53.6**	227.4	**Ratio of corn needed**
Protein in urea (%)	281		44.9	**Ratio of urea needed**
			272.3	Total

Corn needed
to complete supplement (lbs./ton)

$$227.4 \div 272.3 \times 1257.8 = 1050.4$$

Urea needed
to complete supplement (lbs./ton)

$$44.9 \div 272.3 \times 1247.8 = 207.4$$

Table 14. Final supplement formulation and composition.

Roughage	2 lbs. alfalfa daily		Non-legume	
Degree of ration mix	Poor	Uniform	Poor	Uniform
Ration No.	1	2	3	4
Stilbestrol premix (2 gm./lb.) (lbs.)	10.0	20.0	5.0	10.0
Antibiotic premix (50 gm./lb.) (lbs.)	2.8	5.6	1.4	2.8
Vitamin A premix (30,000 IU/gm.) (lbs.)	4.4	8.8	2.2	4.4
Trace mineral premix (lbs.)	10.0	20.0	5.0	10.0
Animal fat (lbs.)	40.0	...	40.0	40.0
Pellet binder (lbs.)	40.0	...	40.0	...
Dehydrated alfalfa—17% protein (lbs.)	200.0	...	200.0	...
Soybean oil meal—solvent (lbs.)	200.0	...	200.0	1300.0
Cane molasses (lbs.)	...	120.0	...	...
Dicalcium phosphate (lbs.)	140.0	260.0	85.0	120.0
Ground limestone (lbs.)	95.0	215.0	105.0	255.0
Corn (lbs.)	1050.8	807.8	1185.4	43.8
Urea (lbs.)	207.0	543.0	131.0	214.0
TOTAL (lbs.)	2000.0	2000.0	2000.0	2000.0
Protein (%)	40.0	80.0	30.0	60.0
Calcium (%)	3.6	7.1	3.1	6.1
Phosphorus (%)	1.5	2.5	1.0	1.5

The final formulation and calculated composition of the four supplements are shown in Table 14.

You can see that supplement formulation is not a simple process. By the time you consider all the available ingredients and attempt to determine least cost formulations, formulating supplements can get quite complex. In fact, computers are being used more and more by feed companies to reduce cost of supplements and to improve their efficiency in formulating supplements.