PRODUCTION AND NUTRITIONAL DEVELOPMENTS

by W. M. Beeson

Scientific knowledge and new techniques rapidly are replacing the "art" of feeding and producing beef cattle. No longer is it true that "the eye of the master fattens the cattle." The human eye is being augmented by the "electronic eye" to formulate rations and "automate" livestock feeding operations. Back of these developments is basic and applied research in nutrition, physiology, genetics, medicine, mathematics and engineering.

To date scientists have only scratched the surface in determining the factors which influence growth, fattening and reproductive processes in beef cattle. Nutrients, physical form of the feed, frequency of feeding, environment, disease, genetics and many other factors directly bear on beef cattle production from the day of conception to the final market product--beef on the table. Today beef is the preferred meat. But beef cannot retain this position without constant attention to unsolved problems. The tempo of beef cattle research must be increased in all areas--breeding, nutrition, rumen physiology, meats, automation, diseases, management and marketing.

This chapter briefly summarizes the present and future possibilities in the following areas as applied to beef cattle: (1) harvesting and preserving feeds, (2) automation and frequency of feeding, (3) roughness factor, (4) the ratio of concentrate to roughage, (5) pelleting, (6) vitamin A, (7) zinc, and (8) certain feed additives and nutrients such as antibiotics, choline, enzymes, dehydrated alfalfa meal, tranquilizers and vitamin E.

Harvesting and Preserving Feeds

Eventually we will harvest and immediately store feeds in the form that they are to be fed to livestock. We will eliminate many of the in-between processes and chores involved in handling the feed several times before it is fed to animals. The best example is the picking of high-moisture ear corn and directly ensiling it or grinding it into a silo (air-tight structure). This process will preserve feed in a form that is high in nutritive value. Research at Purdue and Iowa has shown that the ensiling of high-moisture ground ear corn (30-32%) for cattle improves its feed value 10 to 12 percent on a dry matter equivalent basis as compared to low-moisture ground ear corn. In fattening cattle high-moisture shelled corn has a slightly higher feed value per unit of dry matter than low-moisture shelled corn.

Harvesting equipment is needed that will simultaneously field-shell high-moisture corn into one bin and chop the cobs and stalks into a wagon to make cornstalk and cob silage. Corn yielding 120 bushels or 15 tons of whole corn plant per acre produces the following total digestible nutrients:

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According to these figures, 61% of the nutritional value of a corn crop is in the corn kernel and the remaining 39% in the cobs and the stalks. Enough energy is produced from the stalks and cobs from each 1.5 acre to maintain a beef cow for a year and raise a calf. Cornstalk-cob silage offers a real potential for increasing the beef cow herds in the Corn Belt region.

In the next decade machinery will be developed to harvest the entire corn plant, separate it into its component parts as needed and store it in silos for automatic feeding. No longer will it be necessary to go through the laborious task of picking, cribbing, shelling and grinding corn fed to livestock.

Hay making by the baling process will gradually pass out of the picture, and machinery will be developed to pellet hay in the field ready for feeding. Research at several experiment stations has shown that coarsely grinding and pelleting hay doubles its feed value per ton for beef cattle. Two hundred and twenty pounds of beef were produced from a ton of pelleted hay and only 115 pounds of beef from a ton of the same hay baled. Haylage (ensiling 45% moisture hay in an air-tight silo) is being tested in many feed lots and offers a new way of preserving hay in a palatable and nutritious form.

Methods for preserving and storing all types of feed will be improved so that the original feed value can be retained without deterioration. We are just on the brink of discovering anti-mold and anti-fungal compounds to preserve high-moisture grains and silage. Also, antibiotics and other substances are being developed to control bacterial fermentation so that only the most favorable acids are produced in silage.

### Automation and Frequency of Feeding

Hand-feeding of livestock is rapidly becoming a thing of the past, and in the future all types of meat animals will be fed by "push button" methods. The shovel and pitchfork will be replaced by power equipment, automatic feeders and unloaders, and other mechanical devices, which will reduce the work involved in feeding. Self-feeding will become a common practice. Energy intake will be controlled by compounding complete rations with various proportions of roughages. Instead of gradually being fed more grain cattle and sheep will be started on full feed the first day. In fact, this has already been done for several years in research with cattle and sheep at Purdue University. Digestive disorders and "going off feed" result from a lack of a balanced diet rather than from too much food.
Twice daily feeding of cattle will be replaced by self-feeding or more frequent automatic feeding--maybe six times daily at 4-hour intervals around the clock.

Tests at the University of Illinois (Mohrman et. al., 1959) showed that cattle fed six times a day gained 11 to 21% faster, consumed 5 to 17% more feed daily and required from 3 to 5% less feed per unit of gain than those fed twice a day. Cattle self-fed gained 7% faster than those fed twice daily but required 5% more feed per pound of gain.

Research at Iowa (Woods et. al., 1961) indicated that feeding six times a day as compared to twice a day will increase daily gain 0.83 pound (3.60 vs. 2.70) and improve feed efficiency about 25% (558 vs. 740 lb. feed/100 lb. gain). Apparently feeding of fattening cattle several times a day keeps the rumen microorganisms in a high state of activity and thus improves microbial synthesis.

**Roughness Factor**

Roughage is still an important ingredient in the ration of ruminants. Even though roughage possesses a low energy value, it has other nutritional properties which cannot be replaced by concentrates. Most data show clearly that for best feedlot results, a complete ration should contain not less than 20% roughage or fiber equivalent. Strangely, as good a growth rate and carcass quality can be produced on a ration containing 40% roughage as one containing 20% roughage. Some roughage in the diet keeps the rumen functioning properly. Roughness stimulates the growth of beneficial microorganisms. It has a scouring effect on the rumen, thus improving microbial activity. Even though cattle can be experimentally fattened on no-roughage diets, it may not be wise to make a one-stomach animal out of a ruminant.

The "Roughness Factor" is clearly illustrated by the improved performance of beef cattle obtained by adding 1% or 2% blasting sand to a high concentrate ration (Woods et al., 1961). Adding 1.0% sand to a high concentrate ration improved the average gain by 7.6% and feed efficiency by 4.0%. Adding 2.0% sand gave a 15.2% increase in gain and 9.4% better feed conversion. No benefit was obtained from adding sand to rations which contained adequate and proper amounts of roughage. The authors (Woods et. al., 1961) explain that possibly one of the functions of coarse roughages is to keep the rumen lining scrubbed and active.

How ruminants use energy in feedstuffs is closely related to the amount and ratios of acetic, propionic and butyric acids produced in the rumen. When the animals consume starchy rations lactic acid is often found in the rumen. Normally, organic acids such as n-valeric, isobutyric, 2-methyl butyric and iso-valeric occur in small amounts. Large amounts of volatile fatty acids (VFA) are produced within the rumen through microbial action, and these account for about 50 percent of the energy derived from feed by ruminants. Recent research indicates that the key to improving efficiency of feed conversion in cattle and sheep is to control the end products of microbial metabolism in the rumen.
Shaw et al. (1960) showed that the physical form of the feed has a significant effect on gain and feed conversion. Pelleting alfalfa hay and steam flaking corn increased the daily gain of steers 22% and improved feed efficiency 18 percent. Changing the physical form of the ration increased the propionic acid in the rumen from 16.3% to 41.1% and the total volatile fatty acids from 580 to 1357 milligrams per 100 milliliters of rumen fluid.

This classical discovery has shown that the physical form of a feed for ruminants has a decided effect on its feed value. This phenomena I have named the "Roughness Factor." The physical form of the feed is almost as important as the nutritional form. Physical stimulation or scouring of the rumen lining has a beneficial effect on the performance of ruminants. Finely ground feeds depress grain, feed conversion, milk production and butterfat percentage.

**Ratio of Concentrates to Roughage**

Research data has shown that growing and fattening cattle don't need as much roughage if their rations contain the nutritional and other factors ordinarily supplied by roughages. Specific nutrients are partially replacing the factors formerly supplied by high-quality roughages. Geurin et al. (1960) demonstrated that steers or heifers can be fattened on a ration of 90% rolled barley and 10% well-balanced supplement without any roughage except the fiber furnished by the barley. California feed trials (Henly, 1961) indicated that the primary advantage of high-energy rations (90% barley) was improvement in feed conversion and dressing percentage. Other types of high-energy rations commonly used in the United States are (1) 89% ground ear corn and 11% supplement, (2) 70% rolled shelled corn, 20% sun-cured alfalfa pellets and 10% pelleted supplement, and (3) 60% rolled shelled corn, 30% rolled oats and 10% pelleted supplement. An example of a 32% supplement which will balance grains with no roughage is as follows: 65% soybean oil meal, 14% dehydrated alfalfa meal, 14% cane molasses, 5.2% dicalcium phosphate, 1.8% salt with trace minerals and 10,000 to 20,000 international units (I.U.) of vitamin A per pound.

Seven trials at Kansas and Nebraska, using chiefly milo or corn and alfalfa hay, showed no advantage in extremely high concentrate rations with a concentrate to roughage ratio of 5:1 (Table 1).
Table 1. Effect of Varying the Concentrate-to-Roughage Ratio for Fattening Yearling Steers and Heifers

<table>
<thead>
<tr>
<th>C:R ratio</th>
<th>1:1</th>
<th>3:1</th>
<th>5:1</th>
<th>Moving Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average daily gain, lb.</td>
<td>1.99</td>
<td>2.16</td>
<td>2.22</td>
<td>2.12</td>
</tr>
<tr>
<td>Average daily feed intake, lb.</td>
<td>25.6</td>
<td>21.8</td>
<td>21.5</td>
<td>22.8</td>
</tr>
<tr>
<td>Feed per cwt. gain, lb.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concentrate</td>
<td>642</td>
<td>743</td>
<td>769</td>
<td>710</td>
</tr>
<tr>
<td>Roughage</td>
<td>650</td>
<td>290</td>
<td>198</td>
<td>330</td>
</tr>
<tr>
<td>Yield, %</td>
<td>59.3</td>
<td>60.6</td>
<td>60.5</td>
<td>60.0</td>
</tr>
<tr>
<td>Carcass grade</td>
<td>Gd+ to Ch-</td>
<td>Ch-</td>
<td>Ch-</td>
<td></td>
</tr>
</tbody>
</table>


Research at Illinois (Webb et al., 1959) indicated that cattle grow satisfactorily (1.71 to 1.81 lb. daily) on a pelleted ration of 100% hay, or 15% concentrate and 85% hay. But the carcasses are inferior, grading standard. There was no significant difference in the performance of steers, fed on concentrate to roughage ratios of 60-40 and 80-20 from the standpoint of daily gain or carcass grade. In fact, less total digestible nutrients were required to produce a pound of gain with the 60:40 ratio than with the 80:20 ratio.

The trend toward high energy and low roughage diets for cattle will continue as long as the price of grain is much cheaper per unit of TDN than roughage. However, ruminants need some roughage in the diet to stimulate bacterial synthesis of nutrients and to prevent digestive disturbances. For best results a steer or heifer requires a minimum of 2 to 3 pounds of roughage per head daily. Many times on high concentrate rations steers will do well for a short period of time. But then their rate of gain and feed efficiency drop. This is because the body has been depleted of certain essential nutrients. These nutrients are provided by bacterial synthesis, which is stimulated by roughage.

**Pelleting**

Research reports from several experiment stations have shown that the pelleting of hay and other roughages increases the consumption by ruminants, and improves daily gains and feed efficiency. Tests at Illinois (Webb et al., 1957) showed that beef calves gain 1.73 lb. daily on a pelleted hay and only 0.63 lb. on the same hay baled or chopped. Two hundred twenty pounds of beef were made from a ton of pelleted hay and 115 pounds of beef from a ton of the same hay baled.
Research by Wallace et al. (1961) revealed that beef calves wintered on chopped, wafered and pelleted meadow hay gained, respectively, 0.37, 0.30 and 0.71 pounds a day and required 32.8, 39.5 and 17.8 pounds of hay per pound of gain. Pelleting hay into a 3/8-inch pellet improved the daily gain 136% and feed efficiency 85%. Wafering did not significantly change the feeding value of the hay.

Pelleting high energy diets has not improved the daily gain of cattle but, in some instances, has increased the feed efficiency. A test at Purdue (Perry et al., 1958) showed that the pelleting of a diet containing 70% corn cobs and 30% concentrate improved the daily gain from 1.57 to 1.98 pounds. Steers on the pelleted rations required 14% less feed per unit of gain. Similar diets containing 20-45% corn cobs showed no improvement in daily gain or feed efficiency.

An average of 21 experiments comparing meal and pelleted fattening rations for cattle showed that pelleting a complete ration decreases daily gain 6% and improves feed efficiency 2.8 percent.

There is a great interest in the pelleting of all types of roughage such as sorghum silage and corn silage, and many large feed lots will use this method in their cattle feeding operations in the future. Pelleting has gained in popularity in the formation of supplements for beef cattle. Cattle usually eat pelleted feed much quicker than meal. Pelleting also permits the simultaneous feeding of several nutrients in a condensed form.

Although the fundamental reason is not known, it appears that diets high in fiber are more adapted to pelleting than those high in energy. Condensing a bulky feed like hay allows the animal to consume more, permitting a larger intake of nutrients above maintenance requirements.

**Vitamin A**

Research and feedlot reports show evidence of vitamin A deficiency in beef cattle on rations that were formerly considered adequate in carotene (pro-vitamin A). Evidence suggests that nitrates and/or some unidentified substance inhibits the conversion of carotene to vitamin A in the ruminant animal. Heavy use of nitrogen on crops in recent years has increased the nitrate content of feedstuffs, especially silages and pasture grasses. However, vitamin A deficiency occurs in rations low in free nitrates. Thus nitrogen in feedstuffs is not the sole cause of the problem. Apparently there are other factors which are reducing the efficiency of conversion of carotene to vitamin A. In view of these facts, a majority of beef cattle rations and supplements are fortified with preformed vitamin A.

**Conversion of Carotene to Vitamin A.** The natural plant source of vitamin A for cattle is carotene present in an unstable form in yellow corn, green-colored dry roughages and green pasture. Carotene is readily destroyed by oxidation and high temperatures. After carotene is taken into the body, it must be converted into
vitamin A in the intestinal wall before it can be used. Any naturally occurring substance or condition of the animal which alters the conversion of carotene to vitamin A reduces or stops carotene's activity. In the absence of interfering agents, 100,000 I. U. of vitamin A from carotene has a biological activity equal to 25,000 I. U. of vitamin A from a preformed source for beef cattle. In other terms, one milligram of beta-carotene (1666 I.U.) is equivalent to 400 I. U. of vitamin A for beef cattle. Due to the present uncertainty and variability of the biological activity of carotene in natural feedstuffs, research needs to be conducted to re-evaluate the conversion ratio of carotene to vitamin A in all species of animals.

**Symptoms of Vitamin A Deficiency.** Vitamin A deficiency in cattle is characterized by swelling of the brisket and hind legs, dull watery eyes, stiffness in the hindquarters and night blindness. Simultaneously, feed intake is reduced; gain and feed efficiency are depressed. Cattle on low vitamin A rations suffer more from heat and are usually dull appearing. The hair coat, eyes and muscle tone do not exhibit the bloom and vigor of steers receiving vitamin A.

**Vitamin A Requirements.** Early studies on the carotene and vitamin A requirements of cattle were based on the minimum amount necessary to prevent night blindness and not on the need for maximum performance. Also, in the past 25 years many changes have been made in cattle production which have a definite influence on the vitamin A requirement; namely, (1) increased growth rate, (2) genetic composition, (3) feed composition, (4) environment, (5) thyroid activity, (6) stress, (7) disease, and many other factors. Neither animal nor man lives in a stable state of nutritional needs.

Several experiments in different sections of the United States have shown that vitamin A supplementation is needed in feedlot rations. For example, two experiments at Purdue University (Beeson et al., 1961) have revealed that steers require a supplemental source of vitamin A if fed on a ration containing either 1.0 or 2.26 milligrams of carotene per pound or a daily intake of 18 to 46 milligrams of carotene. This is equivalent to 7,200 and 18,400 I. U. of vitamin A activity using present conversion standards. The ration furnishing the higher level of carotene contained 10% of sun-cured alfalfa pellets. Fortification of either ration with 20,000 I. U. of preformed vitamin A per head daily increased daily gain 15% to 30% and improved feed efficiency 6% to 10 percent. High levels--30,000, 40,000 and 50,000 I.U.--of vitamin A fed during the cool months of the year did not improve performance of the steers over the 20,000 I.U. level. On the basis of these studies and feedlot observations, Purdue workers recommend that a minimum of 20,000 I.U. of biologically active vitamin A be given per steer daily in cool weather and 30,000 I.U. or more during hot weather.

In brief, the vitamin A requirements can be summarized as follows:

1. Growing or fattening steers or heifers - 20,000 I.U. of vitamin A daily in the cool months and 30,000 to 50,000 I.U. daily during the hot months.
2. Breeding cows during the winter months or dry pasture conditions - 30,000 I.U. of vitamin A daily.

3. For cattle shipped to the feedlot from dry ranges in the fall - 50,000 I.U. of vitamin A daily as indicated for the first 14 to 28 days.

4. At present there is no evidence that supplementary vitamin A is needed for cattle being grazed or fed on green pasture.

**Zinc**

With the shift to high concentrate diets for cattle and the loss of certain trace elements by soils and plants there has been a revival of research on the mineral needs of ruminants.

Zinc has been recognized as a required element for ruminants for many years, but only recently has research revealed its essential nature. Miller and Miller (1960) reported a zinc deficiency in young Holstein calves fed a semi-purified diet containing 2.7 p.p.m. (parts per million) of zinc. With the low zinc diet the following early symptoms were observed: red and inflamed nose and mouth, loss of hair from the rear legs, breaks in the skin around the hoofs, rough scaly skin on the rear legs, and retarded growth. After 11 weeks the calves exhibited such symptoms as swelling of the hocks and knees, loss of hair and wrinkled appearance on the legs. Calves on the same basal diet fortified with 46.0 p.p.m. of zinc did not exhibit any symptoms of zinc deficiency.

Haaranen and Hyppola (1961) observed that itch and hair slicking of dairy cattle in Finland could be cured by feeding affected cows 300 to 500 milligrams of zinc per day per 1000 pounds of bodyweight. Milk production of the itching cows (zinc deficient) was 11.4% smaller than that of the non-itching cows. The authors concluded that it has been statistically demonstrated that the itch and hair slicking adversely affect milk production, fertility and tranquility in dairy cattle. Also, this condition can be cured or prevented with zinc chloride, sulphate or oxide.

Recently Beeson et al. (1962) reported that preliminary data indicate a favorable effect from fortifying a fattening ration for beef cattle with zinc. Supplementing a high energy ration of corn, corn cob and soybean meal with 100 p.p.m. of zinc (0.25 lb. zinc oxide per ton) resulted in a 17% increase in daily gain, a 5% increase in feed consumption and an 11% improvement in feed efficiency. Although a good response was obtained in this experiment by adding zinc, additional research is needed to determine beef cattle’s need for zinc under a variety of feeding conditions. During 1962, feeding zinc (100 p.p.m.) in a ration to cattle self-fed on pasture caused no significant change in daily gain or feed conversion. The only observable difference was that the cattle fed zinc had more attractive hair coat and bloom. However, this was only an aesthetic value and was not reflected in the selling price or carcass grade.
Certain Feed Additives and Nutrients

**Antibiotics.** Antibiotics will be more universally used in cattle feeding to improve gain, feed efficiency and carcass quality and to reduce the occurrence of condemned livers. Numerous studies have shown that antibiotics and stilbestrol are complimentary and additive in their effect from the standpoint of gain, feed efficiency and carcass quality. Low level feeding of antibiotics (75 to 80 mg. daily) tends to increase fat deposition in the presence of stilbestrol. Cattle feeders who desire maximum performance and are feeding to grade and specifications are using antibiotics. This trend will increase.

**Choline** is a member of the vitamin B-complex and technically should not be classified as a feed additive unless it acts as a drug instead of a nutrient. It is well-known that choline may be combined with homocystine in the formation of methionine, an essential amino acid.

Interest in choline chloride for ruminants was stimulated by the research of Dyer (1961) of Washington State University. In two out of four trials increases in daily gain were obtained by the feeding of 126 mg. of choline chloride per pound of feed. In this first series of four tests, choline stimulated gains an average of 0.1 pound daily. In the fifth experiment, feeding 3.25 grams of choline chloride per steer daily gave a 7.2% increase in gain and a 2.7% improvement in feed efficiency. There was no change in the digestibility of the dry matter in the rations from feeding choline.

At Purdue (Perry et al., 1962) feeding 3.25 grams of choline chloride per steer daily showed no significant effect on gain or feed efficiency.

More research needs to be conducted with choline to study its mode of action in the ruminant and whether it will promote growth on different types of rations.

In view of new techniques in feeding ruminants, other B-vitamins need critical investigation—especially in the young calf and lamb prior to rumen development.

**Enzymes** are essential for the digestion and utilization of all nutrients in the animal body. In general, the results reported to date on the effect of the amylolytic-proteolytic type of enzymes have been negative and inconsistent. Enzymes are needed that will improve the digestion of roughages. Bacteria in the rumen break down roughages to some degree but not completely. Eventually enzymes will be isolated which can enhance the digestion of cattle feeds. At present the cellulase and fungal type enzyme preparations look the most promising.

**Alfalfa,** especially dehydrated alfalfa meal, and other high quality legumes and young grasses contain unidentified factors which stimulate maximum performance of cattle. Feedlot rations that are properly balanced daily supply 0.5 to 2.0 lbs. of dehydrated alfalfa meal or its equivalent per steer. In the absence of
interfering agents, 100,000 I.U. of vitamin A from carotene (DeHy alfalfa) have a biological activity of 25,000 I.U. of vitamin A for beef cattle. The feedlot of tomorrow will use more alfalfa and grass pellets in the daily ration.

Mineral supplementation shall be tailored according to the character and mineral content of the natural feeds. More attention will be paid to (1) mineral element interrelationships, (2) the effect of chelating agents in making minerals more available for use, and (3) minerals supplied in the drinking water. Urinary calculi and several other feedlot diseases are basically a mineral-vitamin balance problem.

Tranquilizers have helped man respond to his environment. But none of them has achieved any consistent beneficial effects in beef cattle except for medical purposes. Cattle feeders know that calm, quiet cattle are more desirable feeders. Tranquilizers likely will be discovered eventually which improve the performance of beef cattle under specific feedlot conditions.

Vitamin E is essential for reproduction and to protect young lambs and calves against white muscle disease or muscular dystrophy. However, the feeding of 40 I.U. of vitamin E per head daily to steers either singly or with vitamin A (12,500 I.U.) had no beneficial effect on gain or feed conversion (Beeson et al., 1962).


