THE EFFECT OF PHYSICAL BALANCE IN BEEF CATTLE FATTENING RATIONS

by

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INTRODUCTION

It has been generally recognized that the primary object of nutrition is to transform vegetable and mineral matter into an edible and more palatable product for human consumption as economically as possible. In order to achieve this desired transformation, it might be assumed that a ration containing all of the essential food nutrients in an amount which would meet the minimum nutritive requirements for which it was being fed would be essential.

Lavoisier (Maynard, 41), a French chemist in the eighteenth century, has been given the credit for being the founder of the science of nutrition. It was due to his respiratory experiments that the chemical basis of nutrition was established. Carbohydrates, proteins, and fats were the first food nutrients to be studied.

After the work of Lavoisier, scientific workers began to turn their thoughts to the chemical differences in feeds and to their relation to the performance of the animal. Morrison (48) has given an account of the early feeding standards and discussed their limitations. He has also emphasized that feeding standards are only approximate guides in livestock feeding.

While the chemical constituents of a ration may be considered of major importance, it is of interest to note the various results which have been obtained using chemically balanced rations made up of various feeds and in some cases chemically pure elements. The term "physical balance" has been

used to designate the concentrate-roughage ratio as distinguished from chemical balance. This paper is primarily concerned with the effects of the physical balance of a ration, that is, its bulkiness or concentration.

REVIEW OF LITERATURE

Factors Favoring the Digestion of Crude Fiber in Ruminants

In 1930, Woodman (61) stated that investigations had failed to reveal the production of cyto-hydrolytic enzymes by the digestive glands of the higher animals. However, he believed that under the favorable environmental conditions provided in the alimentary canal, the presence of such enzymes in plant materials might cause the hydrolytic breakdown of cellulose to cellobiose and glucose. Earlier work by Brown and Morris (6) showed that these plant enzymes became active in plants only during the process of germination. During this time, the cell wall of the endosperm was broken down, and nutrients were released for the plant embryo. Woodman's theory was further supported by the work of Karrer and Staub (37), who isolated cyto-hydrolytic enzymes from the stomach contents of both cattle and hogs. It was their belief that these enzymes had entered with the food.

Levin (39) considered it probable that the power of the reindeer to subsist on lichens and mosses was dependent upon the action of cyto-hydrolytic enzymes of plant origin, since

arctic animals were found to have few intestinal bacteria. According to Dukes (23):

> The saliva of the ruminant contains no amylase and the rumen and reticulum add no secretion to their contents. However, it is known that a large number of microorganisms, both bacteria and protozoa, exist in the rumen and there is pretty general agreement that they are the main factors responsible for the digestion of carbohydrates.

Morrison (48) has also stated that the ability of livestock to use the fiber and pentosans in their rations was due to the bacterial digestion of these feeds.

Mangold (40) has reported that the rumen flora are transmitted from animal to animal by salivary infection of the common food supply. He also reported that while some species are wide-spread among cattle and sheep, a few animals harbor most of the classified species, and only a few species are harbored by the camel and antelope. Hastings (28) stated that the rumen microorganisms in young animals were derived from the adults at the time of rumen development. He pointed out that the density of bacteria, expressed by billions, was due to the controlled environment as to temperature, to the buffering effect of the saliva, to the arrival at frequent intervals of fresh food, to the constant removal of the by-products of any one kind of organism by others of the complex sequence of life, and through the removal of the cells by the constant stream of saliva and water passing through the rumen to the lower levels of the digestive tract. Many other investigators have reported that the bacterial action of the rumen was made possible by the controlled environment. Doetsch

and Robinson (17) stated that the chemical reaction of the rumen was near neutrality, and that the temperature was nearly constant at 39 degrees centigrade. Mowry and Becker (49) reported that the hydrogen ion concentration of the rumen varied from a pH of 7.6 to a pH of 7.8, while Monroe and Perkins (47) reported a somewhat lower pH value for the rumen contents, ranging from a pH of 6.3 to a pH of 7. Hale, Duncan, and Huffman (27) stated that on a ration of alfalfa hay the pH of the rumen was neutral or slightly acid, the average pH was 6.82, and the maximum acidity was reached about six hours after feeding. Olson (50) determined the pH on the ingesta of the rumen obtained from cows, steers, and aged bulls. Some of the animals were beef strains while others were dairy stock. The carcass grades ranged from choice to canners. He reported that there were no significant differences obtained in the 473 samples, the average being a pH of 6.859.

Mangold (40) has stated that the number of rumen micro-organisms decreased rapidly during fasting or starvation. He also noted that the same effects were produced when hay or cellulose-rich feeds were excluded from the ration. Mowry and Becker (49) reported a decrease in the number of rumen flora during fasting and an increase in the number of flora when grain was added to a ration of hay. Gall and associates (24) stated that the bacteria of the rumen of cattle and sheep on winter rations showed averages of about 50 billion bacteria per gram of fresh rumen contents. They also noted

that both species gave higher counts when on pasture. They reported that the only variable studied which seemed to influence the bacterial population was the ration, and here changes in the flora were not so much qualitative as quantitative. A high grain ration tended to increase the numbers of a type of organism already present in the rumen, rather than causing an entirely different type of bacteria. Gall and associates (25) reported that the types and numbers of rumen microorganisms were noticeably affected by the composition of the ration and that these changes could be related to differences in digestibility of the ration and to the growth responses of the animal.

McAnally and Phillipson (42) reported that the degree of digestion of cellulose by the rumen bacteria was affected by the other constituents of the diet. Tillman and Swift (54) conducted an experiment with lambs in which they used ammoniated condensed distillers molasses solubles, ammoniated cane molasses, urea, and soybean oil meal as nitrogen supplements for a basal ration containing timothy hay, 20.50 per cent; alfalfa hay, 20.50 per cent; shelled yellow corn, 57.50 per cent; mineral mixture, 1.45 per cent; vitamin A and D feeding oil, 0.05 per cent. They stated that there was no significant difference in the digestion of crude fiber from the different rations.

Burroughs and co-workers (8) reported that as little as four or five per cent protein in a ration is ample for good

digestion. However, it was pointed out that this small amount of protein was not enough to meet the requirements of the animal body. This protein requirement for roughage digestion is the protein or nitrogen requirements for rumen bacterial growth. They stated that the protein requirement apparently decreased as starch or starchy grains were reduced in the ration. When sufficient protein was fed and roughage digestion was good, satisfactory numbers of rumen bacteria were present and the predominating types differed morphologically and culturally from those found when roughage digestion was poor.

Burroughs and associates (7) proposed:

> ...that rumen microorganisms have three general nutrient requirements. The first relates to energy, the second to protein and its elements, such as nitrogen, and the third relates to inorganic constituents involved in enzymes or enzyme systems of rumen microorganisms.

They stated that the strongest evidence supporting their theory was the fact that rumen microorganisms could utilize as much ammonia from urea alone as could be utilized from urea in the presence of any conventional protein. In their experiments, the major interest of rumen microorganisms in proteins appeared to be that of energy instead of ammonia.

In an in vitro study of rumen microorganisms, Arias and co-workers (1) found that the utilization of urea could be increased by increasing the energy content of the ration. They also stated that small amounts of readily available carbohydrates aided cellulose digestion, which in turn increased

urea utilization, whereas large amounts of such materials inhibited cellulose digestion.

Burroughs and co-workers (10) stated that while many feeds increased cellulose digestion, meat scraps, fish meal, liver meal, and oats showed little or no favorable influence. Burroughs and associates (9) also stated that apparently rumen microorganisms required varying amounts of a large number of the mineral elements. Huffman and Swigle (34) reported that cobalt given orally had a much greater effect on the animal than when it was injected into the veins. They believed that the cobalt was used to balance the rations of the rumen biota. Burroughs and associates (9) stated that the discovery, in which various minerals were found to be essential to the biota of the rumen, was in keeping with the stimulating effects produced by the complex mineral assortment found in the ashes of plants or plant products.

According to Huffman (33), the ruminant receives only a small portion of its nutrients directly from the food it has eaten. He said that the ruminant must depend almost entirely upon the digestion and absorption of the countless number of food-laden bacteria after they have handled the feed consumed by the host.

Experiments Relating to the Physiological Effects of Rations Composed of Concentrates

Snapp (53) stated that roughage has formed the principal, and probably the only feed for cattle under natural conditions

for countless generations. Huffman (32) said that dairy cattle apparently made good use of the total digestible nutrients when the total ration consisted of alfalfa. He also stated that heavy roughage rations have a tendency to be deficient in phosphorus.

Interest was evidenced quite early by a number of investigators as to the physiological effects of rations devoid of roughages.

Henderson, Larson, and Putney (29) and Armsby (2) have related the experimental work conducted by Mr. L. W. Miller in 1874. Mr. Miller stated that he had successfully wintered his dry cows on a ration of corn meal exclusively, and that although rumination was entirely suspended for several months, no ill effects were observed. According to the report by Armsby, Mr. Miller showed that three quarts of good fine corn meal per day, fed dry without other food, were sufficient to supply the wants of a 900-pound animal.

Sanborn (51) later reported the results of his experiments on exclusive concentrate feeding. He fed a 182-pound calf on grain and milk for a period of 42 days. Five and nine-tenths pounds of food were required per pound of gain. However, the calf died as a result of eating its sawdust bedding. Sanborn also reported the feeding of two sheep on an exclusive diet of grain and roots for a period of about five months, at which time they were slaughtered. He stated that the roots required no more remastication than the grain, and that no course fodder

was given. Both sheep lost weight during the first two months. He attributed this loss in weight to a decrease in the contents of the rumen. Because of this loss in weight which he thought was due to a change in the contents and size of the rumen, all calculations were made from the time when the loss in weight ceased. According to his calculations, the sheep made an average daily gain of .17 pound during the remainder of the experiment. He stated that the stomach, intestines, and fat of sheep on other trials being fed course feed weighed nearly twice as much.

In a third experiment, he fed a two-year-old steer for approximately eight and one-half months on grain alone. He considered the gain in weight during the middle of the experiment which was 1.86 pounds daily, and disregarded the loss at the beginning and end of the trial. The loss during the first part of the experiment was attributed to the decrease in rumen contents. However, there was no explanation for the loss during the last 38 days of the trial.

Davenport (16) conducted four experiments, using calves, in order to determine the physiological requirements of the animal body. He did not have accurate data on his first experiment as no records were kept. However, he described the results quite well from memory. The calf was given grain at an early age, and shavings were substituted for its bedding as soon as it showed a desire for course food. It had a depraved appetite and would eat shavings, ropes, and chew on

sticks when available. Before its death at five months of age, it was consuming more than a half-bushel of grain, composed of one-half corn and one-half oats, a day. A post-mortem examination revealed nothing abnormal in the development of the internal organs. He stated that the one noteworthy feature of the carcass was the absolute lack of fat, either external or internal.

In the second experiment, the calf was put on an exclusive diet of skim milk after the sixth day. It exhibited a strong appetite for course food and eventually refused to get up and take milk. After allowing the calf to become weak to a point near death, he placed hay and straw in the pen before it. The calf ate greedily, ruminated in three hours for the first time in its life, and returned to normal.

In the third experiment, the calf was fed exclusively on grain and milk. The first symptom was that of approaching starvation, an enormous consumption of food which did not satisfy, and later indifference to food. After hay was added to the ration, the calf ruminated in five and one-half hours and rapidly returned to normal.

The calf used in the fourth experiment was weaned early and placed on an exclusive diet of grain. This was the first calf to show signs of a digestive disturbance. After about three and one-half months the calf looked as though it would rally for a short time as had its predecessors in the first three experiments, but it died suddenly without warning.

McCandlish (43) attempted to raise two bull calves on milk alone. He stated that there were no marked digestive disturbances. They ate a small amount of the shavings first used for bedding, gnawed the wood in the walls of the pen, and licked the hair from each other. They grew fairly well until they were two or three months old. During the next 30 days, gains were slow. This was followed by a gradual decrease in weight until the time of their death at from five to six months of age. He also reported that convulsions were frequent. McCandlish believed that the lack of bulk in the ration prevented the normal development of the animal which in turn prevented the proper utilization of the nutrients in the milk. He also noted that the animals consumed excessive amounts of salt.

Mead and Regan (46) showed that dairy calves could be reared to 19 months of age and normal growth secured on a ration containing no roughage, providing cod liver oil and alfalfa ash were supplied in sufficient amounts. While various deficiency symptoms were exhibited, they believed this to be due to a deficiency of vitamin A, an inadequate supply of minerals, or both.

Johnson, Loosli, and Maynard (35) started feeding calves on a purified diet, containing a mixture of casein, lact-albumin, sugar, butter or lard, minerals, and water, at from two to ten days of age. A purified dry ration was kept before them after the first few days and they were completely

transferred to this ration, consisting of casein, starch, sugar, cottonseed meal, cellophane, and minerals, after about three months. These investigators noted that the growth rates of the 15 calves were below normal. They attributed this to poor food consumption and digestive upsets. It also became necessary to add 25 milligrams of magnesium per kilogram of body weight to prevent hypomagnesemia, convulsions, paralysis, and death.

Mead and Goss (45) fed 14 dairy heifers from two days to four months of age on milk. After this time Group I received concentrates, sodium chloride, and cod-liver oil; Group II received concentrates and calcium carbonate; Group III received concentrates, calcium carbonate, and paper pulp. It was necessary to limit the food consumption in order to avoid serious bloat. They stated that 10 of the heifers died at from nine months to four years of age due to the following: four died of bloat, one of chronic indigestion, two of pneumonia complications, one by accident, one of complications following operative procedure for the formation of a permanent rumen fistula, and one following the removal of a large shoulder tumor. Four of the original heifers were still alive at six years of age. They said that with the exception of bloat, none of the symptoms usually associated with a roughage-free diet were noticed.

In an earlier experiment conducted by Mead and Goss (44), 18 heifers were fed from birth to 18 months of age on concen-

trates, and a second group received the same diet plus paper pulp. Pulp was added to the ration so that the fiber content of the ration was equivalent to that of one containing equal parts of concentrates and alfalfa hay. They stated that the digestibility of the crude fiber was 32 per cent lower in the concentrate ration.

These same investigators also studied the effects of fine grinding, and reported that it appeared only to lower significantly the digestibility of the crude fiber of the concentrate ration.

Huffman (31) stated that calves fed on concentrate rations which were adequate for rats and swine would usually die of convulsions. The addition of corn cobs, oat hulls, or shavings to the concentrate ration failed to prevent convulsions. He said that the symptoms were similar to those of animals suffering from a parathyroid deficiency and thought that hay might contain a factor which regulated the functioning of the parathyroid glands.

In his second experiment, he fed wheat straw with a concentrate ration containing adequate protein. This ration failed to bring about normal reproduction when fed to dairy cows. He stated that the calves were born blind and paralyzed. He concluded, as the results of these investigations, that both the quantity and quality of the roughage were important in maintaining the health and normal reproduction in dairy cattle.

Kick and associates (38) studied the effects of chopping alfalfa hay and grinding shelled corn. They found that it made no difference in the number of chews, boluses, or the time spent in rumination; however, they reported that grinding the hay reduced all of these indexes. The most important factor in the amount of rumination was the amount of roughage present in the ration. They stated that steers fed shelled corn and protein supplement without roughage ruminated listlessly and seemed to do it from habit rather than from necessity.

Cole and Mead (12) conducted experiments using cattle and sheep. One group was fed concentrates plus whole alfalfa hay, and the second group was fed concentrates plus finely ground alfalfa hay. The following symptoms were observed in the second group: rumination occurred irregularly or not at all, there were 21 cases of bloat in four cows during a 15-day period and one case in sheep, food consumption was reduced to 6.9 pounds daily per cow, and both cattle and sheep showed depraved appetites. All of the symptoms were more pronounced in the cattle. These investigators thought that the limiting physical factor in an exclusive concentrate diet was the absence of the course sharp material necessary to stimulate the nerve fibers terminating in the ruminal mucosa.

Schalk and Amadon (52) demonstrated that course bulky foods were necessary for rumination. Rumination was experimentally induced by packing the rumen, through a fistula, with

finely chopped and moistened alfalfa hay, sawdust, or shavings. Friction stimuli was produced by drawing handfuls of hay and straw over the surface of the rumen and reticular mucosa and also by drawing the finger tips lightly over these surfaces. They noticed the greatest effects when the anterior portion of the rumen was stimulated.

They stated that the first effects noted, following the stimulation of the rumen mucosa, were the increase in salivary secretion and the more frequent deglutition movements. Heavy concentrates in the form of ground oats, shorts, and shelled whole corn were observed to pass in a large part directly into the reticulum.

Cole, Mead, and Kleiber (13) proposed the theory that the expulsion of gas from the rumen by belching was a reflex mechanism dependent upon an adequate amount of fibrous material of a prickly nature. Their studies on the composition of the rumen gas were made by means of a permanent fistula. It was found that the carbon dioxide content of the rumen gas was slightly higher when feeding alfalfa hay and grain than when feeding either alfalfa hay or green alfalfa alone. They stated that since succulent legumes and concentrates contain a minimum of prickly fiber, sufficient roughage of this nature should be added to the ration to initiate belching and prevent bloat.

Experiments Relating to the Physiological Effects of Rations for Sheep

Coffey (11) has reported that in each of two experiments, the lambs receiving the largest portion of corn made the largest gains. The ratios ranging from 1 part corn and 0.86 part hay to approximately 1 part corn and 2 parts hay were about equal in their effects on market quality. He also demonstrated that the lots fed the greatest proportion of corn to hay produced the cheapest gains.

Blakeslee and Brown (3) stated that lambs fed a ration consisting of 1 part shelled corn and 2 parts alfalfa hay made the most economical gains. The lambs which were fed equal parts of corn and alfalfa hay made good gains, and when corn and hay were fed in the proportion of 1 to 3 the gains were slower and less economical. They stated that the last ration would not be economical unless corn was worth more than 4.2 times per ton as much as alfalfa hay.

In their second experiment (4), four lots of lambs were used to determine the effects of the physical balance of the ration and the effects of hand feeding versus self feeding. The first two lots were given a ration containing 70 per cent hay and 30 per cent corn, and the second two lots were given a ration containing 50 per cent hay and 50 per cent corn. They stated that both lots receiving the greatest proportions of corn had a higher dressing per cent when compared to the first two lots. It was also noted that there was a greater

difference in dressing per cent between the two lots which were self fed than there was between the corresponding lots which were hand fed.

Cox (15) conducted nine experiments in order to determine the effect of the physical balance of the ration on feed utilization by fattening lambs. Each experiment consisted of three lots of lambs which were fed as follows: Lot I, 35 per cent concentrates to 65 per cent roughage; Lot II, 45 per cent concentrates to 55 per cent roughage; Lot III, 55 per cent concentrates to 45 per cent roughage. In two of the experiments, paper pulp and wood pulp were substituted for the roughage part of the ration.

Of the nine experiments, Cox noted that the lambs in Lot II made the greatest total gain per head and the largest daily gains in seven of the experiments. Lot III made the highest gains in two of the experiments while Lot I made the lowest gains in seven of the nine experiments.

The efficiency of feed utilization was highest for Lot II in all nine experiments. Lot III ranked second in feed utilization in seven experiments, and Lot I ranked second in only two experiments.

Cox stated:

> ...that as bulky rations are increased in concentration the gains made and the efficiency of feed utilization by lambs increase up to a certain level; and that as the concentration is further increased, the gains and efficiency of feed utilization turn downward.

Blakeslee and Brown (5) stated that according to their results of three years work, the average daily gain tended to be greater when the ration was made up of 40 or 50 per cent corn. However, they also noted that the lot receiving 60 per cent corn and 40 per cent hay had a slightly higher dressing percentage.

Kammlade (36) stated that it was not advisable to feed corn and hay in a ratio greater than two to one. He also said that in most cases the corn in this ratio would be in excess.

Experiments Relating to the Physical Effects of Rations for Cattle

Conrad and Hibbs (14) reported that in 14, five-day, paired-feeding trials using 18 calves with an average age of 1.2 weeks, a ration containing 2 parts of grain and 3 parts of hay was more efficiently utilized than the rations containing 1 part grain and 4 parts hay or 3 parts grain and 2 parts hay.

Gardner and Stuff (26) fed dairy calves on dry mixtures containing 0, 20, 40, and 60 per cent roughage. The calves receiving the ration containing 40 per cent roughage made the largest daily gains per head.

Hibbs, Pounden, and Conrad (30) have stated that Jersey heifers raised to six months of age on grain to hay ratios of 1 to 2 and 1 to 4 showed little difference in growth. However, they stated that the feed utilization per pound of gain was the greatest in the group receiving 1 part of grain and 2 parts of hay.

Weber (58) fed five lots of yearling steers for 180 days in order to determine the comparative grade of beef produced by steers being fed different quantities of grain. The five lots were fed concentrates as follows: Lot I was given a full feed of ground barley containing cottonseed meal; Lot II was given a 2/3 feed of ground barley containing cottonseed meal; Lot III was given a 2/3 feed of ground barley; Lot IV was given a 1/3 feed of ground barley containing cottonseed meal; Lot V was given 1.11 pounds of cottonseed meal per head daily. Silage was fed as a roughage to all lots. The rate of gain was the highest in Lot I and the lowest in Lot V. Weber stated that there was a direct relationship between the degree of finish and the amount of grain eaten. However, he noted that less grain and more silage were required for 100 pounds gain in Lots II and IV which were fed limited grain rations.

In 1947, Weber, Aicher, and Kessler (59) conducted a series of experiments with yearling steers to determine the economy of full feeding milo grain with sorghum silage and cottonseed cake as compared with rations containing 3/4, 1/2, and a 1/4 full feed of grain. The steers were divided into four lots and given all of the silage they would consume throughout the entire 150-day feeding period.

These investigators observed that the lot on full feed had the greatest average gain per head and required less feed per 100 pounds gain than the other three lots; however, the full fed lot required more grain per 100 pounds of gain than

did the steers on other treatments. The lot on 1/4 full feed showed the lowest average gain and required the greatest amount of feed per 100 pounds of gain. This lot also required the least amount of grain.

They gave the dressing per cents as follows: Lot I, full fed, 59 per cent; Lot II, 3/4 fed, 58.4 per cent; Lot III, 1/2 fed, 55.5 per cent; Lot IV, 1/4 fed, 55.5 per cent. Lot II compared quite favorably to Lot I; however, the carcass grades were somewhat lower. They showed that while the dressing per cents of Lots III and IV were equal, the carcass grades of Lot IV were slightly lower than the carcass grades of Lot III.

A second experiment, using the same rations and feeds, was run the following year by these same investigators (60). They stated that the gains in the second set of trials were slightly higher in all four lots than in the gains made in the previous trials of 1947. The results of the 1948 trials compared quite favorably with the results of the previous year. They attributed the increased gains to the higher grain content of the silage.

Experimenters at Colorado A & M College (55) conducted an experiment using four lots of steers in order to determine the effects of different levels of concentrates and roughages in fattening rations. The rations fed in the four lots were pre-mixed, varying the proportions of concentrates, ground corn, rolled barley, soybean meal, and ground limestone, to

roughage, ground alfalfa hay, on a dry matter basis in the following ratios: 3 to 1, 2 to 1, 1 to 1, 1 to 2. The amount of soybean meal was adjusted in each lot to maintain an equal level of protein, and ground limestone was added in the amounts necessary to maintain the same calcium-phosphorus ratio in all four lots. Salt was given free choice.

They stated that the steers fed the 3 to 1 ratio made the highest daily gains and were marketed after 159 days of feeding. The average carcass yield was 61 per cent, and they graded two prime and eight choice carcasses.

The steers fed on a ratio of 2 to 1 were marketed at the end of 166 days. They stated that these carcasses dressed 62.99 per cent and graded choice; however, about one-half of them were criticized by the grader as lacking firmness. The average daily gains for this lot were slightly less than for the previous lot, though the total gains were the largest of the four lots.

The steers fed on a ratio of 1 to 1 were marketed at the end of 173 days. These carcasses dressed 59.69 per cent and graded choice. However, they stated that with one exception, they were criticized for lacking firmness.

The steers on the 1 to 2 ratio were fed for 187 days. They stated that the carcasses dressed 59.31 per cent, graded average and low choice, and were criticized for being soft, having fat which was a trifle yellow, and being dark in the lean. It was also noted that this lot made the lowest daily

gains when compared with previous lots. The feed cost per 100 pounds gain was also the highest.

These same investigators (56) conducted the same experiment the following year with one exception. An additional lot of cattle was added for which the ratio was changed at four-week intervals from 1:2 to 1:1 to 2:1 and finally to 3:1. The steers on a ratio of 2 to 1 made the cheapest gains and produced the highest yielding carcasses, though the steers on the varying ratio followed closely.

They stated that the results of this experiment were similar to the experiment conducted the previous year with the exception that the 2 to 1 ratio steers showed more favorable results from the standpoint of gains and cost of gains.

In their third experiment (57) the 3 to 1 ratio steers made the highest daily gains but at the highest cost, with the varying ratio steers and the 2 to 1 ratio steers following close behind in gains. In this experiment, the varying ratio steers made the cheapest gains and produced the highest yielding carcasses.

They noted that while the total digestible nutrients decreased from a 3:1 to 1:2 ratio, the decrease in the rate of gains was relatively more rapid. They stated that this was apparently due to the less efficient use of the nutrients present.

In 1949, Dowe and Arthaud (18) conducted an experiment using five lots of yearling steers, each lot being fed corn

and alfalfa in the following ratios: Lot I, 1 to 1; Lot II, 2 to 1: Lot III, 3 to 1; Lot IV, 4 to 1; Lot V, 5 to 1.

They noted that the average daily corn consumption was about equal in Lots II, III, IV, and V; however, this was not planned as the steers were fed free choice. Soybean meal was substituted for part of the corn in Lots IV and V. The steers in Lot V consumed the greatest amounts of total concentrates per head, though this resulted in an additional average daily gain of only .22 pound when compared to the steers in Lot I.

They stated that the steers in Lot III required less total feed per 100 pounds gain than did the steers in the other four lots. The dressing per cent was the highest for the steers in Lot III. However, the carcass grades for Lots II and III were about equal.

Dowe, Arthaud, and Matsushima (19) fed five lots of steers on various ratios of concentrates to roughage for 105 days. Water, salt, bone meal, and ground limestone were available at all times. The steers in Lot I were started on a mixture of 2 parts of corn to 1 part of alfalfa hay. Each 28 days, the amount of corn was increased until the steers were receiving a mixture of 5 parts of corn and 1 part of alfalfa hay at the end of the experiment. The other four lots were given the following ratios of concentrates to roughage: Lot II, 2 to 1; Lot III, 3 to 1; Lot IV, 4 to 1; Lot V, 5 to 1.

These investigators stated that the steers in Lot IV consumed the smallest daily ration of corn per head and made

the smallest daily gains per head. However, the slaughter data indicated that these steers were as well finished as those of the other lots. This lot required more pounds of concentrates per 100 pounds gain than any of the other lots.

The steers in Lot II consumed the smallest total amount of concentrates per head but made the largest average daily and total gains.

They stated that the steers in Lot I consumed more pounds of corn per head daily than any of the other lots. The average daily gain of the steers in this lot was second only to the average daily gain produced by the steers in Lot II.

Dowe, Arthaud, and Matsushima (20, 21 and 22) conducted three additional feeding trials, each trial consisting of six lots of steers, with rations made up for the various lots in each trial as follows: Lot I, 1 part corn to 1 part alfalfa hay; Lot II, 2 parts corn to 1 part alfalfa hay; Lot III, 3 parts corn to 1 part alfalfa hay; Lot IV, 4 parts corn to 1 part alfalfa hay; Lot V, 5 parts corn to 1 part alfalfa hay; Lot VI, a varying ratio starting with 1 part corn and 1 part alfalfa hay which was increased by 1 part corn each 28 days so that by the end of the feeding trial the ratio was 5 parts corn to 1 part alfalfa hay. Soybean meal was added to the concentrate ration in Lots IV, V, and VI in the first two experiments.

According to these investigators, Lot IV made the highest average daily gains in the first two trials. Lot VI made the

highest average daily gains in the third trial. Lot I was consistent in making the lowest average daily gains in all three trials, though Lot I equaled Lot III in the first trial and Lot V was only slightly higher than Lot I in the second trial. They stated that the steers in Lot V showed more signs of scouring and were more erratic in their daily feed consumption than any of the other lots in the second trial.

EXPERIMENTAL INVESTIGATIONS

Experiment I

Plans and Procedures. The purpose of this experiment was to determine the maximum amount of roughage which could be used in a fattening ration for beef cattle that would produce the maximum and most economical gains. It was also the purpose of this experiment to secure information on the relation of the physical balance of the ration to carcass grade and quality. This type of information will aid the cattle feeder in determining how he can best utilize his supply of roughage and grain.

The Hereford steers used in this experiment were purchased at Marathon, Texas. They were delivered to Manhattan, Kansas and placed on their respective fattening rations December 22, 1951. The feeding trial lasted until July 12, 1952, at which time the results were tabulated for the 203-day period.

The 30 steer calves used in this experiment were divided into three lots on the basis of weight, size, and conformation. One steer died in Lot III on June 21, 1952. After this time all calculations for Lot III were based on nine head. Death was attributed to traumatic pericarditis.

The proportion of concentrates in each lot was gradually increased until the desired ratio of concentrates to roughage was obtained. Table 1 gives the respective ratios for the three lots.

Table 1. The following ratios of concentrates to roughage were fed in the respective lots.

Lot	Ratios Fed
I	1 part milo grain to 1 part alfalfa hay
II	3 parts milo grain to 1 part alfalfa hay
III	5 parts milo grain to 1 part alfalfa hay

The steers in all three lots were self-fed their respective ratios of grain to hay. The milo grain was course-ground and the alfalfa hay was chopped into three to four-inch lengths in order to facilitate mixing with the grain. Water and salt were provided free choice at all times. In addition to their respective ration, Lot III received 300 pounds of dehydrated alfalfa pellets plus a capsule containing eight-tenths gram of vitamin A supplement per steer. The potency of the vitamin A supplement was 400,000 units per gram. The pellets and capsules were added due to the poor

quality of the alfalfa hay being used which was evidenced by a vitamin A deficiency.

Results and Discussion. During the 203-day experimental period, the steers in Lot I consumed the largest total amount of feed. They were followed by Lots II and III respectively. The steers in Lot III consumed the largest amount of grain and the least amount of alfalfa hay. The consumption of alfalfa hay was the greatest in Lot I. The average total feed consumed and the average daily feed consumed is presented in Tables 2 and 3 respectively. It was noted that Lot III, followed by Lots I and II, consumed the largest quantity of salt. However, the difference was not as great between Lots III and I as between Lots I and II.

As presented in Table 4, Lot II made the highest average daily gains and average total gains. Lot III made the lowest average daily gains and average total gains. However, it was noted that the average daily gains and the average total gains of Lot III exceeded those of Lot I during the first 129 days of the experiment and were only slightly below the average gains made during this period by Lot II. A comparison of the average weights per head per lot is presented in Fig. 1.

Table 2. Average total feed consumed per head with cumulative averages by lots.

Period	Milo grain in lbs.			Alf. hay in lbs.			Salt in lbs.		
	Lot I	Lot II	Lot III	Lot I	Lot II	Lot III	Lot I	Lot II	Lot III
1st 28 days	124.0	124.0	124.0	373.3	380.0	372.3	2.05	1.50	2.20
2nd 28 days	290.7	359.5	348.5	281.2	176.3	169.8	2.10	2.10	
56-day av.	414.7	483.5	472.5	654.5	556.3	542.1	4.15	3.60	2.20
32 days	370.0	555.5	569.0	370.0	185.0	114.5		1.40	
88-day av.	784.7	1038.5	1041.5	1024.5	741.3	656.6	4.15	5.00	2.20
10 days	140.0	195.0	195.0	140.0	65.0	39.0	.90		
98-day av.	924.7	1233.5	1236.5	1164.5	806.3	695.6	5.05	5.00	3.60
31 days	380.0	510.0	555.0	380.0	170.0	111.0			
129-day av.	1304.7	1743.5	1791.5	1544.5	976.3	806.6	5.05	5.00	3.60
28 days	365.0	510.0	465.0	365.0	170.0	93.0			
157-day av.	1669.7	2253.5	2256.5	1909.5	1146.3	899.6	5.05	5.00	3.60
28 days	360.0	450.0	420.0	360.0	150.0	84.0	1.00		3.30
185-day av.	2029.7	2703.5	2676.5	2269.5	1296.3	983.6	6.05	5.00	6.90
18 days	210.0	180.0	240.7	210.0	60.0	48.1			
203-day av.	2239.7	2877.8	2917.2	2479.5	1353.5	1031.8	5.85	4.40	6.25

Table 3. Average daily feed consumed per head with cumulative averages by lots.

Period	Milo grain in lbs.			Alf. hay in lbs.			Salt in lbs.		
	Lot I	Lot II	Lot III	Lot I	Lot II	Lot III	Lot I	Lot II	Lot III
1st 28 days	4.4	4.4	4.4	13.3	13.6	13.3	0.07	0.05	0.08
2nd 28 days	10.4	12.8	12.5	10.0	6.3	6.1	0.08	0.08	
56-day av.	7.4	8.6	8.4	11.7	9.9	9.7	0.07	0.06	0.04
32 days	11.6	17.4	17.8	11.6	5.8	3.6		0.04	
88-day av.	8.9	11.8	11.8	11.6	8.4	7.5	0.05	0.06	0.03
10 days	14.0	19.5	19.5	14.0	6.5	3.9	0.09		
98-day av.	9.4	12.6	12.6	11.9	8.2	7.1	0.05	0.05	0.04
31 days	12.3	16.5	17.9	12.3	5.5	3.6			
129-day av.	10.1	13.5	13.9	12.0	7.6	6.3	0.04	0.04	0.03
28 days	13.0	18.2	16.6	13.0	6.1	3.3			
157-day av.	10.6	14.4	14.4	12.2	7.3	5.7	0.03	0.03	0.02
28 days	12.9	16.1	15.0	12.9	5.4	3.0	0.04		0.12
185-day av.	11.0	14.6	14.5	12.3	7.0	5.3	0.03	0.03	0.04
18 days	11.7	10.0	13.4	11.7	3.3	2.7			
203-day av.	11.0	14.2	14.3	12.2	6.7	5.1	0.03	0.02	0.03

Table 4. Average daily and total gain per head with cumulative averages by lots.

Period	Lot I		Lot II		Lot III	
	Daily lbs.	Total lbs.	Daily lbs.	Total lbs.	Daily lbs.	Total lbs.
1st 28 days	1.93	54.0	2.04	57.0	1.93	54.0
2nd 28 days	2.57	72.0	2.75	77.0	2.50	70.0
56-day av.	2.25	126.0	2.39	134.0	2.21	124.0
32 days	2.53	81.0	2.66	85.0	2.47	79.0
88-day av.	2.35	207.0	2.49	219.0	2.31	203.0
10 days	2.60	26.0	2.60	26.0	2.80	28.0
98-day av.	2.38	233.0	2.50	245.0	2.36	231.0
31 days	2.05	63.5	2.30	72.0	2.70	84.0
129-day av.	2.30	296.5	2.46	317.0	2.44	315.0
28 days	1.88	52.5	2.20	61.5	1.04	29.0
157-day av.	2.22	349.0	2.41	378.5	2.19	344.0
28 days	2.25	63.0	1.77	49.5	2.11	59.2
185-day av.	2.23	412.0	2.31	428.0	2.18	403.2
18 days	0.88	16.0	1.03	18.5	1.05	19.0
203-day av.	2.10	428.0	2.20	446.5	2.07	422.2

The cost of feed per 100 pounds gain, as presented in Table 5, was based on the following feed prices:

Milo grain per cwt.	$ 2.80
Alfalfa hay per ton	40.00
Salt per ton	12.00

Table 5. The cost of feed per 100 pounds gain.

Lot	I	II	III
Cost of Feed	$26.01	$24.15	$22.88

A comparison of the amount of feed required by the various lots per 100 pounds of gain is presented in Table 6. It was noted that Lot III required the least amount of total

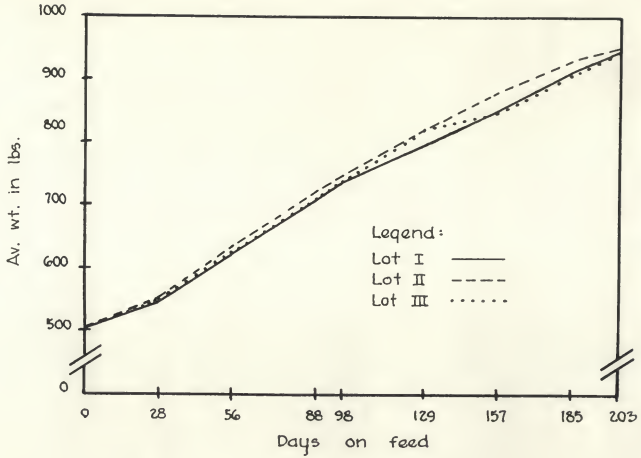

Fig. 1. Average weights per head per lot.

Table 6. Feed required per 100 pounds gain with cumulative averages by lots.

Period	Milo grain in lbs.			Alf. hay in lbs.			Salt in lbs.		
	Lot I	Lot II	Lot III	Lot I	Lot II	Lot III	Lot I	Lot II	Lot III
1st 28 days	229.6	217.5	229.6	691.3	666.6	689.4	3.80	2.63	4.07
2nd 28 days	403.8	466.9	497.9	390.6	229.0	242.6	2.92	2.73	
56-day av.	329.1	360.8	381.1	519.5	415.2	437.2	3.29	2.69	1.77
32 days	456.8	653.5	720.3	456.8	217.7	553.4		1.64	
88-day av.	379.1	474.2	513.1	509.7	338.5	323.5	2.00	2.28	1.08
10 days	538.5	750.0	696.4	538.5	250.0	139.3	3.46		
98-day av.	396.9	503.5	535.3	499.8	329.1	301.1	2.16	2.04	1.55
31 days	598.4	708.3	654.8	598.4	236.1	132.1			
129-day av.	440.8	550.0	568.7	520.9	308.0	256.1	1.70	1.57	1.14
28 days	695.2	829.3	1603.4	695.2	276.4	320.7			
157-day av.	478.4	595.4	656.0	547.1	302.9	261.5	1.44	1.32	1.04
28 days	571.4	900.0	711.9	571.4	300.0	142.4	1.58		5.59
185-day av.	492.6	824.2	664.1	550.9	395.2	244.1	1.46	1.52	1.71
18 days	1050.0	1000.0	833.3	1050.0	333.0	166.7			
203-day av.	518.4	645.2	674.4	574.0	303.5	239.4	1.35	0.98	1.45

feed per 100 pounds of gain, although this lot required the greatest amount of grain per 100 pounds of gain. Lot I required the greatest total amount of feed and the least amount of grain per 100 pounds of gain.

All 29 steers were trucked to Kansas City and slaughtered. The carcass data is presented in Table 7.

Table 7. Carcass data.

Lot	I	II	III
Av. live wt. in lbs.	934	949	933
Per cent shrink to market	2.4	1.9	3.0
Av. dressing per cent	58.6	60.0	60.3
Carcass grades:			
Low prime		1	
High choice		6	2
Average choice	2		5
Low choice	6	1	2
High good	1	2	
Average good	1		
Selling price per 100 lbs.	$32.50	$33.50	$34.00

By assigning numerical values to the carcass grades, a comparison between lots was made. The carcass grades, ranging from average good to low prime, were numbered consecutively from 1 to 6, starting with average good. The average carcass grades were as follows: Lot I, 2.9; Lot II, 4.3; Lot III, 4.0. The carcass grades of the steers in Lot I were lower because of a lack of finish.

Summary of Experiment I. Thirty steers were divided into three lots and placed on different rations which varied in the

proportions of concentrates to roughage. The death of one steer in Lot III was attributed to traumatic pericarditis. Due to the poor quality of the alfalfa hay used, one steer in Lot III became blind, and the others showed symptoms of vitamin A deficiency. This necessitated the use of a vitamin A supplement for Lot III.

During the first 129 days of the experiment, the average daily gains of Lot III exceeded those of Lot I and were only slightly less than those of Lot II. However, during the remainder of the trial, the gains made by Lot I exceeded those of Lot III. The gains made by Lot I were largely due to growth as evidenced by the increased size and lack of finish. The gains made by Lot II were consistently higher throughout the entire feeding period.

Experiment II

Plans and Procedures. The purpose of this experiment was to determine the maximum amount of roughage which could be used in a fattening ration for beef cattle that would produce the maximum and most economical gains. It was also the purpose of this experiment to determine the effects, if any, of previous wintering rations on summer fattening ability and to determine the relative value of milo grain versus corn for fattening rations and carcass quality.

The Hereford heifers used in this test were purchased at Marfa, Texas and were delivered to Manhattan, Kansas on

November 3, 1952. They were placed on a ration of prairie hay and one pound of soybean pellets per head daily until December 22, 1952, at which time they were placed on their respective wintering rations for 108 days. The wintering rations and the number of heifers per lot are given in Table 8.

Table 8. Wintering rations for heifer calves.

Lot	VI	VII	VIII	IX	X
No. heifers per lot	8	10	10	10	10
Treatment	Alfalfa hay	Atlas sorgo silage. 2 lbs. corn. 1 lb. soybean pellets.	Atlas sorgo silage. 3 lbs. special supplement.*	Prairie hay. 4.9 lbs. corn. Soybean pellets.	Corn cobs. 4.9 lbs. corn. Soybean pellets.
Daily gain per heifer in lbs.	1.24	1.72	1.69	1.60	1.43

* The special supplement was of the following composition: soybean oil meal, 2.25 pounds; molasses, 0.50 pound; steamed bone meal, 0.18 pound; salt, 0.06 pound; vitamin supplement, 0.01 pound (2,250 units of A and 400 units of D per gram).

For purposes of physical balance treatments, the heifers on the wintering rations previously mentioned were divided into five lots. Each lot was made up of ten heifers, based on three-day average individual weights and previous treatments. With the exception of Lots IV and V, each of the other lots contained two heifers each from Lots VI, VII, VIII, IX, and X. Lots IV and V contained one heifer each from Lot VI,

and one additional heifer each which had been wintered on grass to make up the total of ten heifers in each of these lots.

The heifers in all five lots were self-fed their respective ratios (Table 9) of grain to hay. Water, salt, and ground limestone were provided free-choice at all times. Soybean oil meal pellets were fed once daily to the lots on high concentrate rations of corn in order to compensate for the low protein content of the corn. In these lots, one pound of soybean oil meal was used to replace one pound of corn, thus keeping the ratio of concentrates to roughage constant.

Table 9. The following ratios of concentrates to roughage were fed in the respective lots.

Lot	Ratios fed
I	3 parts milo grain to 1 part hay.
II	A moving ratio was fed. The first 28 days, 1 part corn to 1 part hay was fed, and each succeeding 28 days the corn was increased 1 part so that at the end of the feeding period the ratio was 4 parts corn to 1 part hay.
III	1 part corn to 1 part hay.
IV	3 parts corn to 1 part hay.
V	5 parts corn to 1 part hay.

The milo grain and corn were course-ground and hay was chopped into three to four-inch lengths in order to facilitate its mixing with the grain. Brome and alfalfa hay were mixed in equal proportions by weight in all of the rations.

Chemical analyses of the feeds used in this experiment are given in Table 10.

Table 10. Chemical analyses of the feeds used.

Feed	SOM	Yellow corn	Milo maize	Alf. hay	Brome hay
Protein (%)	46.13	9.06	11.06	16.19	8.88
Ether extract (%)		4.32	2.95	2.01	2.12
Crude fiber (%)		4.03	2.80	25.71	32.77
Moisture (%)		9.45	9.17	7.69	6.98
Ash (%)		1.50	2.26	9.18	7.32
N-free extract (%)		71.64	71.76	39.22	41.93
Carbohydrate (%)		75.67	74.56	64.93	74.70
Calcium (%)		.01	.04	1.57	.29
Phosphorus (%)		.30	.34	.18	.13
Carotene (mg/lb.)		1.23 *		7.85	2.18

* Potency from crude carotene 2.6 units per gram
Potency from crude cryptoxanthin 1.7 units per gram
Total 4.3 units per gram

Results and Discussion. During the 91-day experimental period, beginning May 14, 1953 and ending August 13, 1953, the heifers in Lot I consumed the largest total amount of feed. They were followed by Lots III, V, IV, and II respectively. Lot I also consumed the largest amount of grain for the period. Lot V consumed the second largest amount and was followed by Lots IV, II, and III. A summary of the average total feed consumption is given in Table 11. While Lots I and IV were on the same respective ratios, the increased feed consumption of Lot I was apparently due to the increased palatability of the milo grain in their ration over that of

Table 11. Average total feed consumption per head with cumulative averages by lots.

Period	Grain in lbs.					Hay in lbs.					SOM in lbs.		
	Lot I	Lot II	Lot III	Lot IV	Lot V	Lot I	Lot II	Lot III	Lot IV	Lot V	Lot II	Lot IV	Lot V
1st 28 days	403	245	310	383	406	270	330	320	260	270			
2nd 28 days	508	370	320	378	426	170	210	320	130	110		5.5	8.0
56-day av.	911	615	630	761	832	440	540	640	390	380		5.5	8.0
3rd 28 days	510	367	320	406	476	170	130	320	140	100	13.0	14.5	23.2
84-day av.	1421	982	950	1167	1308	610	670	960	630	480	15.0	20.0	31.2
7 days	140	110	85	96	127	47	28	85	33	27	3.9	3.5	5.6
91-day av.	1561	1092	1035	1263	1435	657	698	1045	663	507	16.9	23.5	36.8

the corn in Lot IV. The average daily feed consumption per head is presented in Table 12.

Early in the experiment it was noted that there were fewer digestive disturbances in Lot I than in any of the other four lots. However, there were only three cases of bloat in the entire experiment. Two of these were in Lot III, and one was in Lot V. The bloat in Lot III was attributed to an excess consumption of corn due to its sifting down through the hay in the ration. The one case in Lot V was also attributed to an excess consumption of corn.

As presented in Table 13, Lot V made the highest average daily gains and total gains. Lot V was followed by Lots I, IV, III, and II respectively. A comparison of the average weights per head per lot is presented in Fig. 2. While Lots I and IV were fed the same ratios, Lot I averaged .30 pound per head per day more than Lot IV and was second only to Lot V whose daily gain exceeded that of Lot I by .10 pound. There was no apparent explanation for the relatively low gains made by Lot II. However, it was noted previously that the amount of feed consumed by this lot was the lowest of the five lots. With the exception of Lot III, the average daily gains of all of the lots showed a downward trend during the last two feeding periods which consisted of 35 days. The marked decrease during the last seven-day period was probably due to the short period, hot weather, and increased handling due to weighing.

Table 12. Average daily feed consumption per head with cumulative averages by lots.

Period	Grain in lbs.					Hay in lbs.					SOM in lbs.		
	Lot I	Lot II	Lot III	Lot IV	Lot V	Lot I	Lot II	Lot III	Lot IV	Lot V	Lot II	Lot IV	Lot V
1st 28 days	14.4	8.8	11.1	13.7	14.5	9.6	11.8	11.4	9.3	9.6			
2nd 28 days	18.1	13.2	11.4	13.5	15.2	6.1	7.5	11.4	4.6	3.9		0.20	0.29
56-day av.	16.3	11.0	11.3	13.6	14.9	7.9	9.6	11.4	7.0	6.8		0.10	0.14
3rd 28 days	18.2	13.1	11.4	14.5	17.0	6.1	4.6	11.4	5.0	3.6	0.46	0.52	0.83
84-day av.	16.9	11.7	11.3	13.9	15.6	7.3	8.0	11.4	6.3	5.7	0.15	0.24	0.37
7 days	20.0	15.7	12.1	13.7	18.1	6.7	4.0	12.1	4.7	3.9	0.56	0.50	0.80
91-day av.	17.1	12.0	11.4	13.9	15.8	7.2	7.7	11.5	6.2	5.6	0.19	0.26	0.40

Table 13. Average daily and total gain per head with cumulative averages by lots.

Period	Lot I		Lot II		Lot III		Lot IV		Lot V	
	Daily lbs.	Total lbs.	Daily lbs.	Total lbs.	Daily lbs.	Total lbs.	Daily lbs.	Total lbs.	Daily lbs.	Total lbs.
1st 28 days	1.82	51.0	1.48	41.5	1.46	41.0	2.23	62.5	2.18	61.0
2nd 28 days	2.63	73.5	2.20	61.5	2.30	64.5	2.00	56.0	2.52	70.5
56-day av.	2.22	124.5	1.84	103.0	1.88	105.5	2.12	118.5	2.35	131.5
3rd 28 days	2.45	68.4	1.70	47.5	1.66	46.5	1.86	52.0	2.45	68.5
84-day av.	2.30	193.0	1.79	150.5	1.81	152.0	2.03	170.5	2.38	200.0
7 days	1.93	13.5	1.57	11.0	2.07	14.5	1.21	8.5	1.86	13.0
91-day av.	2.27	206.5	1.77	161.5	1.83	166.5	1.97	179.0	2.34	213.0

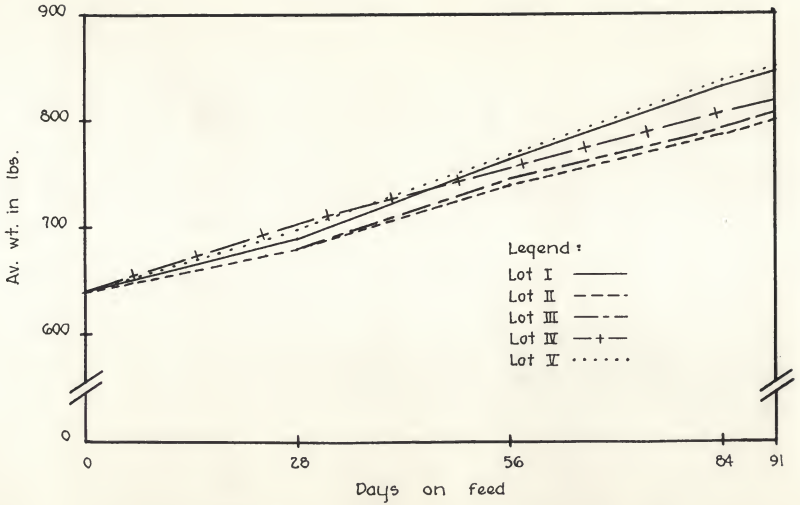

Fig. 2. Average weights per head per lot.

All of the gains made during this experiment were probably lower than if the cattle had been fed during the cooler months of the year. During short periods of cooler weather, the daily feed consumption showed a marked increase.

According to previous wintering treatments, the heifers in Lot IX, prairie hay, made the highest average daily gains. They were followed by Lots VIII, special supplement; VII, silage; VI, alfalfa hay; and X, corn cobs, respectively. There was a difference of .12 pound between Lots IX and VI, and a difference of .25 pound between Lots VI and X. This apparent decrease in the ability of heifers to gain on a fattening ration after having been wintered on corn cobs might for the present be assumed to be due to a depletion of certain body nutrients or other unknown factors. While the heifers in Lot X were lighter in weight, they were valued one dollar per hundred weight higher than the heifers in Lot IX at the time they were removed from their wintering ration. A summary of the results obtained according to previous wintering treatments is presented in Table 14 and Fig. 3.

The cost of feed per 100 pounds gain, as presented in Table 15, was based on the following feed prices:

Corn per bushel	$ 1.60
Milo grain per cwt.	2.80
Soybean pellets per ton	95.00
Brome hay per ton	25.00
Alfalfa hay per ton	40.00

Table 14. Average daily and total gain per head with cumulative averages according to previous treatments.

Period	Lot VI		Lot VII		Lot VIII		Lot IX		Lot X	
	Daily lbs.	Total lbs.	Daily lbs.	Total lbs.	Daily lbs.	Total lbs.	Daily lbs.	Total lbs.	Daily lbs.	Total lbs.
1st 28 days	1.93	54.0	1.50	42.0	1.77	49.5	1.88	52.5	1.34	37.5
2nd 28 days	2.14	60.0	2.13	59.5	2.43	68.0	2.32	65.0	2.07	58.0
56-day av.	2.04	114.0	1.81	101.5	2.10	117.5	2.10	117.5	1.71	95.5
3rd 28 days	1.95	54.5	2.27	63.5	1.88	52.5	2.00	56.0	1.77	49.5
84-day av.	2.01	168.5	1.96	165.0	2.02	170.0	2.07	173.5	1.73	145.0
7 days	1.00	7.0	1.79	12.5	1.71	12.0	1.86	13.0	1.14	8.0
91-day av.	1.93	175.5	1.95	177.5	2.00	182.0	2.05	186.5	1.68	153.0

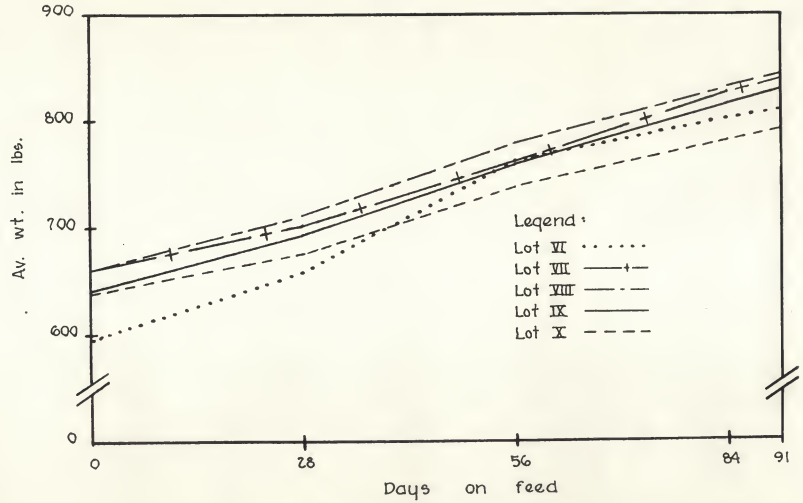

Fig. 3. Average weights per head based on previous treatments.

Table 15. The cost of feed per 100 pounds gain.

Lot	I	II	III	IV	V
Cost of feed	$26.35	$25.59	$26.81	$24.57	$22.69

Salt and ground limestone were fed free-choice and no record was kept as to the amount consumed. Therefore, the cost of feed per 100 pounds of gain does not include either salt or ground limestone.

A comparison of the amount of feed required by the various lots per 100 pounds of gain is presented in Table 16. It was noted that while Lot III required the least amount of grain per 100 pounds of gain, Lot V required the least amount of total feed per 100 pounds of gain. A comparison of Lots I and IV shows that the heifers in Lot I required five per cent more concentrates and 1.1 per cent more roughage per 100 pounds of gain than did the heifers in Lot IV.

The 50 heifers used in this experiment were trucked to Kansas City and placed on the market August 17, 1953. The per cent of shrink to market was not available as the last weigh period was August 13, 1953. The weights and carcass data presented in Table 17 was obtained from Swift and Company of Kansas City. The U. S. marbling standards by which these heifers were graded are presented in Table 18. All carcass grades were obtained through the courtesy of the government graders at the packing plant.

Table 16. Feed required per 100 pounds gain with cumulative averages by lots.

Period	Grain in lbs.					Hay in lbs.					SOM in lbs.		
	Lot I	Lot II	Lot III	Lot IV	Lot V	Lot I	Lot II	Lot III	Lot IV	Lot V	Lot II	Lot IV	Lot V
1st 28 days	790	590	756	613	666	529	795	780	416	443			
2nd 28 days	691	602	496	675	605	231	341	496	232	156		9.82	11.35
56-day av.	732	597	597	642	633	353	524	607	329	289		4.64	6.08
3rd 28 days	745	772	688	781	695	248	274	688	269	146	27.37	27.88	33.87
84-day av.	736	652	625	684	654	316	445	632	311	240	8.64	11.73	15.60
7 days	1037	1004	586	1129	977	346	250	586	393	205	35.45	41.17	43.08
91-day av.	756	676	622	706	674	318	432	628	315	238	10.46	13.13	17.28

Table 17. Carcass data.

Lot	I	II	III	IV	V
Av. live wt. in lbs.	795	757	752	783	810
Av. hot wt. in lbs.	479	452	446	469	494
Av. dressing per cent	59.4	58.0	58.3	58.8	60.0
Carcass grades:					
Low prime	1		1		
High choice					1
Av. choice		1		2	1
Low choice	4	2		3	4
High good	4	1	2	3	3
Av. good	1	3	4	2	1
Low good		3	2		
High commercial			1		
Marbling:					
Slightly abundant	1		1		
Moderate					1
Modest		1		3	1
Small	5	3	2	2	5
Slight	4	2	3	1	2
Traces		4	4	4	1
Av. external finish (thickness in cm.)	1.48	.83	1.51	1.28	1.34
Selling price per 100 lbs.	$21.00	$19.50	$20.50	$21.00	$22.00

Table 18. U. S. marbling standards.*

1. Very abundant	Prime
2. Abundant	Prime
3. Mod. abundant	High choice
4. Slightly abundant	Young prime
5. Moderate	Young choice
6. Modest	Mature good
7. Small	Very young choice
8. Slight	Young good
9. Traces	Young low good
10. Practically devoid	
11. Devoid	

* PMA 99 - December, 1950

The carcasses of Lot I when compared to Lot IV showed a poorer outside finish on the forequarters and rounds. The carcasses of Lot I tended to be dark cutters and the meat was not as firm as in the carcasses from Lot IV. The carcasses of Lot IV had a better color of flesh and texture. However, the average external finish of Lot I was greater than the average external finish of Lot IV.

The external finish of the carcasses was measured in centimeters at the cut surface between the twelfth and thirteenth ribs. The average external finish of Lot III was the greatest. Lot III was followed by Lots I, V, IV, and II respectively. A comparison of the average external finish of the carcasses failed to show which of the lots produced the highest daily gains.

By assigning numerical values to the carcass grades, a comparison between lots was made. The carcass grades, ranging from high commercial to low prime, were numbered consecutively from 1 to 8, starting with high commercial. The average carcass grades were as follows: Lot I, 4.7; Lot II, 3.5; Lot III, 3.3; Lot IV, 4.5; Lot V, 4.8. With the exception of Lots II and III, the average carcass grades were indicative of the average daily gains.

Summary of Experiment II. Fifty heifers were divided into five lots and placed on different rations which varied in the proportions of concentrates to roughage. During the 91-day feeding period, the heifers receiving the largest

amounts of concentrates in relation to the roughage fed produced the largest and most economical gains.

The heifers on a ration composed of milo grain showed less digestive disturbances and made better gains than did heifers on a similar ration composed of corn. However, more feed per 100 pounds of gain was required where milo grain was being fed.

The average carcass grades of the five lots were indicative of the rations being fed. The lots receiving the largest amounts of concentrates produced the highest grading carcasses. The carcasses of the heifers fed milo grain were criticized for having a tendency to be dark cutters, lacking certain portions of outside finish, and having a tendency to be soft.

GENERAL DISCUSSION

The results of these experiments involving the physical balance of rations for fattening beef cattle indicate that there is an optimum concentrate-roughage ratio for the production of maximum gains and for the production of the most economical gains. These experiments also indicate that the length of the feeding period, the quality of roughage, the type of concentrate, the time of the year, and previous treatments are important factors in the promotion of gains by beef cattle.

The first experiment showed quite clearly that the high concentrate-roughage ratio of five to one was inferior to either of the other ratios. The steers on the three to one ratio produced the maximum daily gains and were followed by the steers on the one to one ratio. The difference in daily gain between Lots I and II was .10 pound, while the difference between Lots II and III was .13 pound. The quality of the alfalfa hay used in this experiment quite probably influenced the gaining ability of the steers. It is also reasonable to assume that the inferior quality of the hay would have a more pronounced effect in Lot III since their total hay consumption was less than in the other two lots. The vitamin A deficiency of Lot III became apparent after about 129 days of feeding, and there was also a marked decrease in the rate of gains at this time.

During the 91-day feeding trial in the second experiment, the heifers on the high concentrate-roughage ratio of five to one made the maximum and most economical gains. However, no deficiency symptoms were noted, and the average daily feed consumption was greater than in the corresponding lot of the previous experiment.

The heifers in Lot I of the second experiment, receiving a three to one ratio of milo grain and hay, had a greater average daily feed consumption than did the corresponding lot in the first experiment. However, the average daily gains produced by these heifers were lower than the corresponding

gains produced by steers in the first experiment. While these reduced gains might in part be due to the gaining ability of the animals involved, it is quite probable that the major difference was due to the hot weather encountered during the second experiment. It might also be assumed that the feed consumption in the first experiment would have been greater if the roughage had been of better quality.

A comparison of the heifers in experiment two on a ration of three parts corn to one part of hay versus the steers in experiment one on a ration of three parts milo grain to one part of hay showed a slight increase in feed consumption in the second experiment for the corresponding 91 and 88-day feeding periods. However, the average daily gains in the second experiment were only 1.97 pounds as compared to the corresponding gains of 2.49 pounds in the first experiment. As has been stated previously, such factors as weather conditions and quality of roughage were probably of major importance in producing these seemingly erratic results.

A comparison of the milo-fed heifers versus the corn-fed heifers in the second experiment showed an increased feed consumption and an increase in the average daily gains for the milo-fed heifers. However, their carcasses were criticized in the packing house for lacking the proper external finish and for lacking firmness.

In the second experiment, a comparison of five previous treatments was made in relation to gaining ability when placed

on a summer fattening ration. The heifers which had been wintered on corn cobs produced the least average daily and total gains for the feeding period involved. The heifers wintered on prairie hay showed the greatest average daily and total gains. However, with the exception of the corn cob-fed heifers, the differences in average daily and total gains were not great.

The results of these experiments compared quite favorably to the results obtained by Weber (58) and Weber and associates (59 and 60) in previous years. However, it was noted that the highest concentrate-roughage ratio used in these experiments was approximately 3 to 1. The roughage used in their experiments consisted of silage, containing varying amounts of grain.

Experimental work at Colorado A & M College (55, 56 and 57) showed that steers on a 3 to 1 ratio made the highest daily gains in two of three trials conducted. The steers on a varying ratio were in second place in all experiments where this ration was used. The average daily gain of the heifers on a varying ratio at Kansas State College rated fifth in the five lots used.

Results obtained from the experiments conducted at the Nebraska Agricultural Experiment Station (18, 19, 20, 21 and 22) indicated that the optimum concentrate-roughage ratio for steers was between 3 to 1 and 4 to 1. The results

reported in Experiment I of this thesis compared favorably with these results.

SUMMARY

In two experiments, a study was made to determine the optimum concentrate-roughage ratio for fattening beef cattle. A comparison was also made on previous wintering treatments and the kind of concentrates used.

Both trials indicated that maximum gains could be obtained for short feeding periods on a high concentrate-low roughage ratio, providing the roughage used was of sufficiently high quality. When milo grain was used in place of corn, the total feed consumption increased with a subsequent increase in daily gains. The increased gains produced a slightly higher average carcass grade, but the quality of the carcass was lower when compared to the corn-fed animals.

Low levels of poor quality alfalfa hay in a high concentrate fattening ration necessitated the addition of a vitamin A supplement after about 130 days of feeding.

Previous wintering treatments had little effect on subsequent gains except where the animals had been wintered on an exceedingly poor quality roughage. Of the five previous treatments studied, a wintering ration using corn cobs as a roughage proved inferior.

CONCLUSIONS

The following conclusions are based on the data obtained from the preceding physical balance experiments involving 80 head of beef type cattle.

1. More grain and less hay is required per 100 pounds of gain on a high concentrate-low roughage ratio.

2. When milo grain is used as the concentrate, the palatability of the ration and the subsequent total feed intake is increased.

3. When compared to corn-fed animals, carcass quality is slightly reduced when milo grain is used as a concentrate.

4. For high concentrate-low roughage ratios, a high quality roughage is essential.

5. For short feeding periods, the optimum concentrate-roughage ratio is five to one.

6. For long feeding periods, the optimum concentrate-roughage ratio is about three to one.

7. Previous treatments make little difference in gaining ability unless the feed is of exceptionally poor quality.

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THE EFFECT OF PHYSICAL BALANCE IN BEEF CATTLE FATTENING RATIONS

by

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Interest was evidenced quite early by a number of investigators as to the physiological effects on ruminants of rations devoid of roughage. Most of the early experimental work indicated that while it was possible to maintain ruminants on such a ration for short periods of time, it was not practical.

While it was realized that the quantity of feed consumed was of primary importance in determining the level of production, experimental evidence indicated that there was an optimum concentrate-roughage ratio. The term "physical balance" has been used to designate this concentrate-roughage ratio, that is, its bulkiness or concentration.

Physical balance studies with lambs have indicated that the gains and efficiency of feed utilization are increased as the concentrate in the ration is increased up to 40 or 50 per cent. Gains and feed efficiency were lowered when this ratio was exceeded.

Recent investigations have indicated that the optimum concentrate-roughage ratio for fattening beef cattle is higher than that required for fattening lambs. In two experiments conducted at Kansas State College, a study was made to determine the optimum physical balance of a ration for fattening beef cattle. A comparison was also made on previous wintering treatments and the kind of concentrates used.

The first experiment, involving 30 head of Hereford steers which were divided into three lots, indicated that the optimum concentrate-roughage ratio was about 3 to 1 for a 203-day

feeding period. Milo and poor quality alfalfa hay were used to make up the three rations in this experiment. The other two ratios used were 1 to 1 and 5 to 1.

In the second experiment, involving 50 head of Hereford heifers which were divided into five lots, four of the rations were composed of corn and a mixture of alfalfa and brome hay. The fifth ration was composed of milo and a mixture of alfalfa and brome hay. Soybean pellets were used to supplement the lots receiving large quantities of corn.

Concentrate-roughage ratios of 1:1, 3:1, 5:1, and a ration which changed from 1:1 to 2:1 to 3:1 to 4:1 each 28 days were used in this study.

During the 91-day feeding trial it was observed that more grain and less hay was required per 100 pounds of gain on high concentrate-roughage ratios. When milo was used as a concentrate, the palatability of the ration and the subsequent total feed intake was increased. The use of milo as a concentrate slightly reduced the quality of the carcasses.

The optimum concentrate-roughage ratio for the 91-day period was 5:1. Previous wintering treatments made little difference in the gaining ability of the animals except where a poor quality roughage was used.