EFFECT OF VARYING THE CONCENTRATE-TO-ROUGHAGE RATIO IN SELF-FED MIXTURES FOR FATTENING STEERS AND HEIFERS

By

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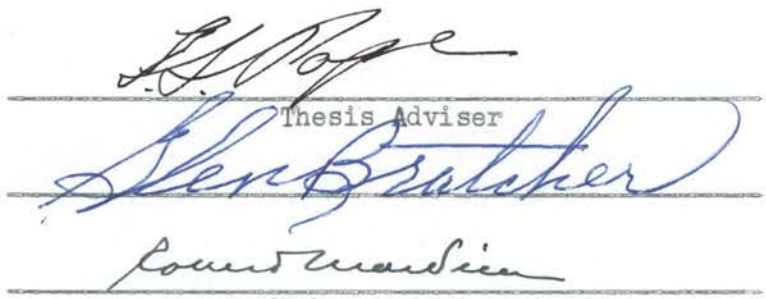

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INTRODUCTION

Although cattle can utilize large amounts of roughage advantageously, the general belief among feeders is that only a small amount should be used in a fattening ration for best gains and finish. Opinions vary as to the proportion of concentrate-to-roughage a fattening ration should contain in order to obtain maximum performance in the feedlot.

Many experiments have been conducted to determine an optimum C:R[1] ratio for fattening beef cattle; however, somewhat conflicting results have been reported. Differences in the age and sex of cattle used, as well as quality and kind of feed, may have contributed to the differences in results.

There is considerable variation in the proportion of concentrate used in fattening rations by successful feeders, with satisfactory results. Since availability and price of roughage vs. concentrate may vary considerably from area to area and year to year, a single ratio might not be advantageous under all conditions. It is of importance, therefore, to determine if an optimum C:R ratio exists for fattening cattle.

Since both steers and heifers are fattened in feedlots, it is also important to determine if there is a sex difference in ability

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[1]C:R is used to denote concentrate:roughage.

to utilize different C:R ratios. It has been shown that heifers tend to fatten at a younger age than steers; therefore, the optimum ratio may be different for steers and heifers.

Much interest has developed in the use of pelleted or cubed rations, both for growing and fattening cattle. This method of feed preparation may be beneficial in reducing storage and handling costs and in improving feed efficiency. However, only limited data are available on the nutritive value of pelleting rations for beef cattle.

Three feeding trials were conducted at the Ft. Reno station to study the performance of beef calves self-fed mixed rations containing different C:R ratios, ranging from 35:65 to 80:20. Studies were made on rate and economy of gain, feed consumption, efficiency of feed use, time required to reach slaughter grade, and carcass merit. The performance of steers and heifers was compared on each ratio. In addition, two trials were conducted to study the effects of pelleting a roughage mixture as well as a highly concentrated fattening ration on rate of gain, feed consumption, and efficiency of feed utilization. Also, the effect on carcass grade was determined in the fattening trial.

REVIEW OF LITERATURE

Since a number of factors must be considered in comparing results from experiments in which varying ratios of C:R have been studied, the review of literature has been divided into sections according to the effect of C:R ratio on: Rate of gain, feed consumption, feed efficiency, time required to reach market grade, carcass merit, and economic aspects. Available literature comparing steers vs. heifers and the effect of pelleting feeds has also been included.

Effect of C:R Ratio on Rate of Gain

For a number of years, attempts have been made to determine the optimum physical balance between concentrate and roughage in fattening rations for cattle and sheep. Cox (1948), after a thorough series of experiments designed to study C:R ratios for lambs, concluded that an optimum physical balance actually exists in lamb fattening rations. The ration which gave the greatest gain with the least amount of feed per pound of gain contained a 45:55 ratio of C:R. He further observed that gains were not always positively correlated with either dry matter or total digestible nutrient intake, but appeared to follow a certain balance between these two factors determined by the crude fiber:total digestible nutrient ratio.

Similar results were presented by Bell et al. (1955, 1956). These workers observed that pelleted rations made up of 65 percent

alfalfa hay and 35 percent corn gave better results with lambs than did pelleted rations containing the same feeds in a 55:45 ratio. However, unpelleted rations composed of 55 percent alfalfa and 45 percent corn produced larger and more efficient gains than the unpelleted rations containing the higher percentage of alfalfa hay. In a further study with lambs, Menzies et al. (1957) found that best results were obtained with a 65 percent roughage and 35 percent concentrate ration in either the pelleted or unpelleted form.

A wide range of C:R ratios for fattening beef cattle has been tested with quite varied results. Stanley (1953) found that average daily gains of yearling steers decreased as the level of roughage was increased above one-third of the ration. Similar results were obtained by Pahnish et al. (1956) in a group feeding trial using 154 yearling Hereford steers. These workers fed the following C:R ratios: 2:1, 1:1, 1:2 and 1:3. Results from this test showed that average daily gains decreased as the proportion of roughage was increased, but the difference was significant only between the 2:1 and 1:3 ratios. Results from these tests indicate that the level of roughage in the ration should not exceed a ratio of one part roughage to two parts concentrate for maximum gain.

Dowe et al. (1955) conducted four group feeding trials in which five ratios of concentrate (corn, or corn and soybean oil meal) to alfalfa hay were employed, ranging from 1:1 to 5:1. Steers 18 months of age were used in three tests while calves 12 months of age were used in one trial. Average daily gains were lowest on the 1:1 ratio and highest on the 2:1 ratio. Steers fed the 3:1 and a changing ratio, in which the proportion of concentrate was increased every 28 days,

produced similar gains and ranked next to those fed the 2:1 ratio in rate of gain. Keith et al. (1952) individually fed 60 grade Hereford steer calves and 40 yearling steers the following six ratios of concentrate-to-alfalfa hay: 4:1, 3:1, 2:1, 1:1, 1:2 and 1:3. Most rapid average daily gains were shown by steer calves fed the 2:1 ratio and by yearling steers receiving the 3:1 ratio. These tests indicate a difference between calves and yearling steers in ability to utilize concentrates.

Richardson et al. (1953) group-fed steers on rations containing C:R ratios of 1:1, 3:1 and 5:1. All lots made satisfactory gains but the group fed the 3:1 ratio made the largest average daily gain. In two trials, calves fed the 3:1 ratio made the most rapid gains, while in the third trial, steers on the 2:1 ratio made the largest daily gains.

Effect of C:R Ratio on Feed Consumption

Another factor closely related to adequacy of the ration is daily feed consumption. Dowe et al. (1955) reported that total feed consumption per 100 pounds live weight decreased as the proportion of roughage in the ration was decreased. It was found that increasing the proportion of concentrates above a 2:1 C:R ratio did not result in a proportional increase in concentrates in all cases. Steers fed rations of 2:1, 3:1 and a changing ratio consumed as much grain as those fed 4:1 and 5:1 C:R ratios. When ratios of 1:1, 2:1, 3:1, 4:1, 5:1 and the changing ratio were compared, it was observed that steers fed the 1:1 ratio consumed the greatest amount of total feed.

A similar test with yearling heifers by Richardson et al. (1956) involving C:R ratios of 1:1, 3:1, 5:1 and a changing ratio showed that feed consumption was greatest on the 1:1 ratio while the other three were about equal. Keith et al. (1952) tested six concentrate-to-hay ratios ranging from 1:3 to 4:1 on steer calves, and five ratios ranging from 1:3 to 3:1 with yearling steers. Results of the feeding trial with steer calves showed average daily feed intake to be greater on the 2:1, 1:1, and 1:2 ratios than on the 1:3 and 4:1 ratios, indicating that C:R ratios ranging from 1:2 to 2:1 are the most desirable for the normal functioning of the digestive system.

Effect of C:R Ratio on Feed Efficiency

To a great degree, efficiency of feed use is related to both the kind and proportion of feeds in the ration. Keith et al. (1954, 1955) found that total feed required per 100 pounds of gain decreased with an increase in the proportion of concentrate in the ration. Although relative differences in rate of gain among groups were not as great as relative differences in feed required per cwt. gain, these differences were of the same order. This agrees with previous work by the same authors (1952) wherein concentrate-to-hay ratios ranging from 1:3 to 4:1 were tested. Feed required per cwt. gain decreased as the level of roughage decreased. Pahnish et al. (1956) and Richardson et al. (1956) also reported that the amount of feed required per cwt. gain increased as the level of roughage in the ration was increased. However, in both tests the pounds of total digestible nutrients required per pound of gain were about equal for all rations.

Effect of C:R Ratio on Time Required to Reach Market Grade

An important factor which should be considered in feeding trials is the length of time necessary for cattle to reach the desired slaughter grade. Obviously, this is closely related to rate of gain and feed efficiency. In order to determine the time required for cattle on different rations to reach a prescribed grade they must be removed from test individually as they attain the desired grade. In the literature reviewed, all of the cattle were fed for the same length of time within each experiment. Thus, no comparison was possible concerning the time required for cattle on different C:R ratios to reach a desired slaughter grade. This factor may be important from the standpoint of overall economy and profit. According to Snapp (1952), it is difficult for cattle fed limited amounts of grain to reach a desired slaughter grade and cannot be counted upon for satisfactory gain after about 150 days.

Effect of C:R Ratio on Carcass Merit

Very little information has been reported on the effect of the physical balance of the ration upon carcass quality and dressing percent. Bell et al. (1955, 1956) and Menzies et al. (1957) found very little difference in carcass grades of lambs fed rations containing 55 or 65 percent alfalfa hay, whether the ration was fed in meal or pelleted forms. Richardson et al. (1956) reported that carcass quality and dressing percent of steers and heifers were lowest on the 1:1 C:R ratio and about the same on the 3:1 and 5:1 ratios; those fed the changing ratio (concentrate increased every 28 days) were lower than those on the 3:1 and 5:1 ratios.

Knox (1951) compared "light," "medium" and "heavy" grain feeding of yearling steers. The cattle were fed all the roughage they would eat and a constant amount of grain. The roughage was composed mainly of corn silage. The amounts of grain fed were 5.3, 7.6 and 9.7 pounds per head daily for "light," "medium" and "heavy" grain feeding, respectively. He found that the amount of grain fed was reflected in the finish of the cattle. However, lots receiving the "medium" and "heavy" amounts of grain were about equal in finish. Also, he noted that cattle fed the "light" grain ration had the lowest dressing percent. Dowe et al. (1955) observed that average dressing percentage of cattle in four experiments were in this order: Steers fed the changing ratio and the 5:1 ratio were highest; 2:1 and 3:1 second; 4:1 third; and the 1:1 C:R ratio produced the lowest dressing percent. Carcass yields were quite uniform for all four trials within each ration. Brethour et al. (1958), in a grain-to-silage fattening test with yearling steers, also reported that market values and carcass grades improved as the proportion of grain in the ration was increased.

Effect of C:R Ratio on Economic Aspects

Among the factors most important to the cattle feeder are economy of gain and profit. Griffith et al. (1957) concluded that the 2:1 C:R ratio gave the most rapid gain and required less feed per unit of gain, but was the most expensive per cwt. gain. Keith et al. (1952) concluded that, although steer calves gained faster on the 2:1 ratio and required less feed per cwt. gain on the 4:1 ratio, the most economical ratio to feed to steer calves for average price

relationships will range between a 2:1 and 1:2 ratio of concentrate-to-alfalfa hay. These workers also stated that the results indicate that yearling steers fed a concentrate-to-hay ratio of 1:1 or 1:2 would produce the most economical gains for average feed price relationships. Using the cost of gain values calculated in these trials, a nomograph was constructed for feed costs per 100 pounds of gain of steer calves fed six different ratios of concentrate-to-alfalfa hay.

Steers vs. Heifers

It has been reported by Loeffel (1953) and Langford and Douglas (1956) that steers make more rapid gains and are more efficient in the feedlot than heifers. However, no information is available on the comparison of steers and heifers on different C:R ratios. In addition to differences in rate and efficiency of gain, Dyer and Weaver (1955) found that heifers tended to fatten at a younger age than steers. Thus, the optimum C:R ratio may conceivably be different for steers and heifers; however, no trials have been conducted to determine if such a difference actually exists.

Effect of Pelleting Feeds on Beef Cattle Performance

Pelleting or cubing feeds has been attempted in an effort to improve gains, feed efficiency and economy of production. Although pelleted feeds have been profitably fed to poultry and swine for several years, the beef and sheep industries have been slower to use pelleted feeds primarily because, in many cases, the cost of fine grinding and pelleting the roughage exceeds any improvement

in performance. This method of feed preparation may find a use if the cost of pelleting can be offset by increased gain and feed efficiency.

Brown et al. (1952) stated that some of the advantages of pelleted over nonpelleted rations are: Preservation of higher carotene content; greater cleanliness and ease of handling; and less "balling up" and molding of feed following adverse weather conditions. Another advantage of pelleting is that of a more uniform intake of ration constituents. Webb and Cmarik (1957) conducted two tests to compare the feeding value of a forage consisting of two-thirds timothy and one-third alfalfa fed as long hay, chopped hay, hay pellets (three-sixteenths inch in diameter) and silage. Roughage in each of these forms was self-fed to grade Hereford steer calves for a period of 119 days. It was found that the pellet-fed calves gained an average of 1.73 pounds daily compared to 0.63 and 0.62 pound for long and chopped hay, respectively. Gains from calves fed the silage were considerably lower. In addition, calves fed the pelleted forage ate more feed and were more efficient in feed conversion, with less feed wastage than the other groups.

By pelleting the entire ration, the C:R ratio can be controlled more accurately since cattle cannot sort out parts of the ration. The quality of the feeds used apparently is an important factor to consider when pelleting a ration. Cate et al. (1955), in a self-feeding trial with lambs, studied the effects of pelleting rations containing roughages of different quality upon rate and economy of gain. They found that pelleting rations containing timothy meal as the roughage gave an increase in average daily gain, average daily

feed consumption, feed efficiency and carcass merit. However, pelleting rations containing alfalfa hay failed to significantly improve these factors.

In a fattening trial using Hereford steers fed roughage free-choice and a limited amount of grain, Ensminger et al. (1948) compared forages of different quality, fed in different forms. The roughages compared were sun-cured ground alfalfa and a dehydrated grass mixture composed of orchard grass, ladino clover, alsike clover and timothy. The dehydrated grass mixture was fed in three forms: Finely ground, coarsely ground, and pelleted. Results showed that the pelleted forage was more palatable than the others, as indicated by larger daily feed consumption and a keener appetite. Furthermore, steers fed the pelleted roughage made faster, more efficient and more economical gains.

Blaxter and Graham (1956), working with lambs, investigated the digestibility of nutrients and the utilization of energy in dried grass when fed in coarsely chopped or cubed forms. Two types of cubed dried grass, designated as "medium ground and cubed" and "finely ground and cubed," were fed. Two levels of each were fed, 600 grams and 1500 grams per lamb per 24 hours. Digestibility and energy utilization were measured in respiration chambers.

Digestibility coefficients for the "chopped" grass were higher with each nutrient studied than for either type of cubed dried grass, with the exception of ether extract. The higher digestibility coefficients were found at the lower level of feeding, with one exception. The digestibility of ether extract was highest with the high level feeding of "medium ground and cubed" grass. There were

no statistically significant differences in energy retention between the three forms of dried grass at either the high or low level of feeding. Fecal losses of energy were higher and methane losses were lower when cubed grass was fed. Determination of the digestibility of the carbohydrate fractions showed that a decrease in digestibility of the structural components of the cell was the major factor causing the higher fecal losses from cubed grass. It was theorized that the physical factors which change the rate of passage of feed through the digestive tract, change the rate and nature of microbial fermentation, or cause variation in the mechanical work involved in prehending, masticating and cudding feed, are as important as the chemical composition of the feed in determining its nutritive value.

Summary

A study of the literature reveals that, in general, rate of gain and feed efficiency tend to increase as the percentage of concentrates in the ration is increased; whereas, feed consumption tends to follow a reverse pattern. Further, carcass quality and dressing percent are generally improved by the use of high concentrate rations. The improvement in performance does not always justify the use of the higher proportions of concentrates due to increased costs per unit of feed. Fluctuations in the relative costs of concentrates and roughages are a major factor in determining the C:R ratio to use. Although much of the literature indicates that a C:R ratio of 2:1 or 3:1 would be the most practical for optimum performance of beef cattle, satisfactory results have been achieved on a rather wide range of ratios. Tests show that steer calves can

more efficiently utilize a greater proportion of roughage in the ration than yearling steers.

In spite of the numerous attempts to establish an optimum C:R ratio for fattening beef cattle, the problem still remains to be answered. Furthermore, even though it has been determined fairly conclusively that steers are more efficient in the feedlot than heifers, no attempt has been made to determine if there is a sex difference in ability to utilize different C:R ratios. Thus an experiment was initiated in an attempt to determine the optimum ratio, or ratios, of C:R for fattening steer and heifer calves, and to study the effects of pelleting feeds.

EXPERIMENTAL

A series of three trials was initiated in September, 1955, at the Fort Reno Station, in which a total of 236 Hereford calves were used. The calves were purchased from a different commercial herd each year. In the first trial, three C:R ratios (50:50, 65:35, and 80:20) were compared, while in two subsequent trials a 35:65 ratio was included in addition.

Equal numbers of good-to-choice Hereford steer and heifer calves, approximately eight to ten months of age and similar in grade, were selected for each test. The cattle were purchased in July or August and supplemented on native grass pasture to maintain condition, before starting on feed in late September. For the first trial, 60 calves were selected from a commercial herd near Ringling, Oklahoma. Eighty calves were purchased from the Harding Ranch, northeast of Stillwater, Oklahoma, to be used in the second experiment. In the third trial, 96 calves were obtained from the Lazy S Ranch near Springer, Oklahoma. Calves used in the first and second trials had been creep-fed during the summer; whereas, those used in the last trial had not been creep-fed.

Allotment was based on shrunk weight (16 hours off feed and water) and feeder grade. Steers and heifers were alloted separately to allow a comparison of performance on each ration. In each trial, the treatments were replicated, with two replications of each treatment in the first two trials, and three replications in the third

test. The cattle in the first experiment were divided into three lots of ten calves per lot within each sex. Each lot was further divided into two pens of five calves each and assigned to one of the three rations. In the second trial, the calves were divided, within each sex, into eight pens of five calves per pen. Two pens of each sex were assigned to each of the four rations. In the third trial, the cattle were alloted, within each sex, to twelve pens of four calves each. Three pens within each sex were assigned to each of the four rations.

In all tests, the rations were fed, free-choice, in self-feeders. All cattle were started on their respective rations with the exception of those receiving the 80:20 mixture. In the first two tests these calves were started on the 65:35 mixture and gradually changed to the 80:20 mixture over the first three weeks of the trial. Calves to be fed the 80:20 ratio in the third trial were also started on the 65:35 ratio, but were changed to the 80:20 mixture after ten days. Ample water and a mineral mixture containing two parts salt and one part steamed bone meal were available in each pen.

The rations fed are shown in Table I, while the chemical composition of the rations, as well as estimated TDN and net energy values, are presented in Table II. The concentrate portion of each ration consisted of ground milo, cottonseed meal and molasses; while the roughage was composed of equal parts of cottonseed hulls and alfalfa hay. All rations were approximately equal in calcium and phosphorus content. The protein content of all rations was maintained at about the same level by varying the amount of cottonseed meal.

TABLE I COMPOSITION OF RATIONS FED[1]

C:R Ratio	35:65	50:50	65:35	80:20
Trial I				
Feeds used (%)				
Ground milo	———	36.50	53.00	69.30
Cottonseed meal	———	8.50	6.70	5.00
Molasses	———	5.00	5.00	5.00
Chopped alfalfa	———	25.00	17.50	10.00
Cottonseed hulls	———	25.00	17.50	10.00
Grd. limestone	———	0.00	0.30	0.70
Trials II and III				
Feeds used (%)				
Ground milo	17.00	33.20	49.70	65.10
Cottonseed meal	11.00	9.50	7.70	7.00
Molasses	7.00	7.00	7.00	7.00
Chopped alfalfa	32.50	25.00	17.50	10.00
Cottonseed hulls	32.50	25.00	17.50	10.00
Grd. limestone	0.00	0.30	0.60	0.90

[1]Feed prices are shown in Appendix Table XV.

TABLE II CHEMICAL COMPOSITION OF RATIONS (%)[1]

C:R Ratio	35:65	50:50	65:35	80:20
Trial I				
Dry matter	-----	90.22	89.58	88.96
Ash	-----	4.75	3.96	3.23
Crude protein	-----	13.07	12.36	11.68
Ether extract	-----	2.21	2.42	2.63
Crude fiber	-----	17.96	13.07	8.18
N-free extract	-----	52.26	57.63	62.88
Estimated TDN[2]	-----	61.56	66.46	71.27
Estimated net energy[3]	-----	55.74	61.97	68.08
Trial II				
Dry matter	90.55	91.21	90.18	88.52
Ash	5.62	6.55	4.61	4.76
Crude protein	14.36	16.17	13.24	13.49
Ether extract	1.02	1.49	1.43	2.60
Crude fiber	26.27	22.29	16.40	9.66
N-free extract	43.28	44.01	54.50	58.01
Estimated TDN	55.70	60.40	65.20	69.80
Estimated net energy	49.06	55.24	61.47	67.58
Trial III				
Dry matter	90.25	89.57	88.89	88.25
Ash	4.71	5.16	4.71	4.30
Crude protein	12.16	12.13	12.01	12.26
Ether extract	2.15	2.30	2.44	2.59
Crude fiber	31.73	17.30	12.83	8.47
N-free extract	42.96	47.82	52.80	57.34
Estimated TDN	56.60	61.35	66.10	70.83
Estimated net energy	49.06	55.24	61.47	67.58

[1]Composition was determined by chemical analysis of ration components in each trial.

[2]Values for TDN and net energy were determined from Morrison (1956).

[3]Estimated net energy is expressed in therms.

The cattle were weighed at 28-day intervals throughout the test. In order to determine the time required for cattle on each ration to reach slaughter grade, the calves were selected individually for slaughter without regard to sex or treatment, and shipped to Oklahoma City when it was estimated that they had reached a slaughter grade of high-good to low-choice. In each trial, three shipments were made. Final shrunk weights were taken (16 hours off feed and water) prior to each shipment.

Records were maintained on average daily gain, feed consumption, and length of time required to reach market grade. Marketing and slaughter data collected included dressing percentage, carcass grade, marbling score and current value for each carcass. A representative of the meats section of the Animal Husbandry department determined carcass grades in all tests. A live, or "on foot," value was calculated from the actual carcass value, based on the final live weight of each animal. Carcass values were calculated using the price scale for the various grades of beef, shown in Appendix Table XVI.

Effect of Pelleting Feeds

Two feeding trials were conducted at Fort Reno in the winter of 1957 and spring of 1958. The first test was designed to compare pelleted and chopped roughage when each was fed free-choice, or in equal and controlled amounts. In addition, a palatability trial was conducted with a small number of calves to determine if there was a preference for either form of roughage.

The roughage mixture was composed of equal parts of average quality alfalfa hay and cottonseed hulls, with five percent molasses added to each mixture. The alfalfa hay was finely ground in preparation for pelleting. Pellets, three-fourths inch in diameter, were made from the mixture. The chopped roughage was identical to the pelleted roughage mixture except that the alfalfa hay was coarsely ground in the chopped mixture.

A concentrate mix composed of milo and cottonseed meal was fed in equal amounts to cattle of all lots. A small amount of dried molasses was added to the concentrate mixture about mid-way through the trial to assure equal consumption of concentrates. A mineral mixture of two parts salt and one part steamed bone meal was available to all cattle free-choice.

Twenty-eight Hereford calves from the experiment station herd were selected after weaning in late September. The calves were divided into four lots of six calves each on the basis of sex, age, shrunk weight, grade, and sire. Each lot contained three steers and three heifers. An extra lot of four calves (three steers and one heifer) was used for the palatability test of chopped vs. pelleted roughage.

The calves were started on feed in early November after a short adjustment period following weaning. Lots were assigned to treatment at random. Two lots of calves were fed the pelleted roughage, while two other groups received the same roughage in the chopped and mixed form. One lot fed each type of roughage was given roughage free-choice, while the other received a controlled amount. The free-choice roughage was offered in self-feeders, while the limited

roughage and concentrate were fed in open bunks. The four calves in the additional lot had access to both forms of roughage in self-feeders placed side by side. Initially the calves were fed in large sod pens, but were later moved to smaller paved lots with an open shed. The trial lasted for a period of 108 days, at the end of which a shrunk weight (off feed and water for 16 hours) was taken.

Data were obtained on average daily gain, feed consumption, and feed required per cwt. gain. No market or carcass data were available since the cattle were to be used in a subsequent trial.

The second test, initiated in February, 1958, was a fattening trial in which a comparison was made between a completely pelleted ration and the same ration in the mixed, but loose form. The ration selected for this test was the 80:20 C:R mixture previously described. The concentrate portion of the ration consisted of ground milo, cottonseed meal, and molasses. Equal parts of average quality alfalfa hay and cottonseed hulls made up the roughage. This ration was chosen because feed intake had been lowest on this C:R ratio in previous trials. The effect of pelleting on feed consumption and efficiency of feed use was studied. Pellets made from the mixture were three-eights inch in diameter. The alfalfa hay was not as finely ground as in the preceding trial.

Twenty-four of the cattle used in the previous trial were selected for this test. The cattle were divided into four lots of six calves each on the basis of sex, age, sire, previous treatment, grade and shrunk weight. Each lot contained three steers and three heifers. Two lots were randomly assigned to each of the two treatments. The cattle were maintained in large sod pens with an open shed, under

which the self-feeders and watering devices were located. As in the previous experiment, a mineral mix of two parts salt and one part steamed bone meal was offered free-choice.

At the end of the 110-day feeding period, a shrunk weight (16 hours off feed and water) was taken and the cattle shipped to Oklahoma City for slaughter. Two calves from each lot were retained for use in another experiment. Records were maintained on average daily gain, feed consumption, and feed required per cwt. gain. Market and slaughter data, on the cattle sold, were collected as previously described.

The data in each experiment were analyzed according to methods described by Snedecor (1956). An outline of the analysis used is presented in Appendix Table XIV. Duncan's multiple range test, described by Federer (1955), was used to compare differences between means. Due to missing data, the first and third trials were of unequal subclass numbers, while the others contained equal subclass numbers. A comparison of "between pen" and "within pen" mean squares of average daily gain was made to estimate the efficiency of the design.

RESULTS AND DISCUSSION

Results of the trials involving different C:R ratios are presented, followed by a discussion of the pelleting trials. Results of the first three trials shall be discussed by topic according to the effect of C:R ratio on: Rate of gain, feed consumption, feed efficiency, time required to reach market grade, carcass merit and economic aspects.

Effect of C:R Ratio on Rate of Gain

Average weight gains of steers and heifers for the three trials are presented in Table III. Data from animals which were removed from experiment due to sickness, etc., are not included in the average pen data. Pen averages were substituted for missing values.

In each trial, average daily gains, within sex, were quite similar for all lots despite the wide variation in C:R ratios. Statistical analysis of the individual trials failed to show any significant differences in rate of gain between treatments. There was no significant interaction between treatment and sex in spite of the apparent ability of heifers to gain most efficiently on the 50:50 C:R ratio.

In the first two trials, average daily gains in all lots were low. Periodic weights from these trials indicate that within each treatment, gains were satisfactory for approximately 100 days,

whereupon feed consumption declined and gains dropped accordingly. The fact that the calves had been creep-fed and were in fleshy feeder condition at the beginning of the trial might have contributed to the reduced gains. Also, the calves in Trial I were of wild disposition. Gains in the third trial were considerably better than in the previous trials. These calves had not been creep-fed and were more consistent in feed consumption and rate of gain. Also, only four calves were fed in each pen in the third trial; whereas, in the previous trials each pen contained five calves.

Average daily gains of steers were quite variable over the three trials, with no definite trend established. This is contrary to the results obtained by Pahnish et al. (1956), who found that average daily gains of yearling steers decreased as the proportion of roughage increased from one-fourth to two-thirds of the ration. Dowe et al. (1955) observed that steers fed a 1:1 C:R ratio made the lowest gains and those receiving a 2:1 ratio exhibited the most rapid gains, while steers fed 3:1, 4:1, 5:1 and a changing ratio were intermediate. In the first trial, somewhat faster gains were made by steers fed the 65:35 C:R ratio, while in the second trial steers receiving the 35:65 mixture made slightly greater gains than calves on the other rations. Similarly, in Trial III, average daily gains of steers fed the 35:65 and 80:20 C:R ratios were about equal and were somewhat larger than those on the 50:50 and 65:35 ratios.

Heifers which were fed the 50:50 C:R ratio consistently made the most rapid gains, while those fed the 80:20 mixture consistently produced the lowest gains. These results are in disagreement with those obtained by Richardson et al. (1956), wherein heifers receiving

TABLE III WEIGHT GAINS OF STEERS AND HEIFERS ON DIFFERENT C:R RATIOS

Sex	Steers				Heifers			
C:R Ratio	35:65	50:50	65:35	80:20	35:65	50:50	65:35	80:20
Trial I[1]								
Ave. weights (lb)								
Initial 9-28-55	-----	542	542	536	-----	511	511	511
Gain to 134 days[2]	-----	261	269	250	-----	225	210	175
Gain to market	-----	278	295	263	-----	248	219	219
Ave. daily gain[3]	-----	1.98	2.04	1.91	-----	1.70	1.59	1.48
Trial II								
Ave. weights (lb)								
Initial 9-14-56	552	552	552	551	505	504	504	504
Gain to 128 days[2]	258	242	218	242	202	212	212	201
Gain to market	328	276	265	267	255	255	225	242
Ave. daily gain	2.02	1.88	1.70	1.88	1.58	1.65	1.66	1.57
Trial III[4]								
Ave. weights (lb)								
Initial 9-26-57	555	558	560	560	527	527	530	528
Gain to 144 days[2]	323	317	313	321	287	303	280	271
Gain to market	406	394	375	413	345	332	336	328
Ave. daily gain	2.23	2.20	2.16	2.23	1.66	2.10	2.04	1.55

[1]One steer was removed from the 80:20 ratio due to sickness of unknown cause.

[2]The first group of cattle were shipped to market at this time.

[3]Average daily gains in all trials are calculated from the gain to first shipment.

[4]One steer and one heifer were removed from the 65:35 ratio due to persistent bloating. Another heifer on the same ratio was bred and had to be removed.

the 1:1 C:R ratio produced smaller gains than those fed the 3:1 and 5:1 ratios.

Effect of C:R Ratio on Feed Consumption

Average daily feed consumption and calculated TDN and net energy intakes are presented in Table IV. As previously mentioned, feed intake in the first trial was lower than in the two subsequent trials. The reason for the low feed intake is not known; however, the fact that these cattle were rather wild throughout the feeding period might be one cause. In Trials I and III, feed intake declined as the proportion of concentrates in the ration increased. Although a similar trend was established in Trial II, the pattern of feed intake was somewhat more variable. Feed intake of steers in the second trial followed about the same pattern, with the exception that steers fed the 80:20 ratio consumed slightly more feed than those on the 65:35 ratio. Feed intake of heifers was greatest on the 50:50 C:R ratio and lowest on the 65:35 mixture.

Statistical analysis showed that in Trial I, the decline in feed intake as the concentrate increased was significant ($P < .01$) between all three ratios tested. In the second trial, feed intake was significantly greater ($P < .01$) on the 35:65 and 50:50 C:R ratios than on the 65:35 and 80:20 mixtures. Daily feed consumption in the third trial was greatest for steers and heifers fed the 35:65 C:R ratio and lowest for those receiving the 80:20 ratio. The differences were significant at the .01 level of probability. There was no significant difference between the daily feed intakes of calves on the 50:50 and 65:35 mixtures.

TABLE IV AVERAGE DAILY FEED, TDN AND NET ENERGY INTAKE BY STEERS AND HEIFERS ON DIFFERENT C:R RATIOS

Sex	Steers				Heifers			
C:R Ratio	35:65	50:50	65:35	80:20	35:65	50:50	65:35	80:20
				Pounds				
Trial I								
Concentrate	-----	10.31	12.63	12.68	-----	9.67	11.02	12.27
Roughage	-----	10.31	6.80	3.17	-----	9.67	5.94	3.07
Total	-----	20.62	19.43	15.85	-----	19.34	16.96	15.34
TDN[1]	-----	12.68	12.91	11.30	-----	11.91	11.27	10.93
Therms net energy[2]	-----	11.49	11.04	10.79	-----	10.78	10.51	10.44
Trial II								
Concentrate	7.97	10.97	12.39	15.64	6.99	10.77	11.64	15.31
Roughage	14.81	10.97	6.67	3.91	12.97	10.77	6.27	3.83
Total	22.78	21.94	19.06	19.55	19.96	21.54	17.90	19.14
TDN	12.69	13.25	12.43	13.65	11.12	13.02	11.67	13.36
Therms net energy	11.18	12.12	11.72	12.21	9.79	11.90	11.00	12.93
Trial III								
Concentrate	8.67	11.46	14.77	16.05	8.42	11.49	14.19	15.10
Roughage	16.11	11.46	7.95	4.01	15.64	11.49	7.64	3.77
Total	24.78	22.92	22.72	20.06	24.06	22.98	21.83	18.87
TDN	14.03	14.07	15.02	14.21	13.62	14.09	14.43	13.37
Therms net energy	12.16	12.67	13.97	13.56	11.80	12.69	13.42	12.75

[1]TDN was calculated from actual feed analysis using digestion coefficient values of Morrison (1956).

[2]Net energy was calculated using net energy values of Morrison (1956).

Cattle receiving the 80:20 C:R ratio exhibited a craving for more roughage during the latter part of the trial, as evidenced by calves sorting the mixture to obtain roughage, and leaving the grain. Refused grain in the troughs of the feeders was placed back into the hoppers once daily.

Although there were large differences among the rations in estimated TDN and net energy content, the average daily TDN and net energy intakes of steers and heifers were quite similar on all rations within each trial. It can be seen from Table II (Experimental), that the differences between rations in net energy content are greater than differences in TDN content. This is due to the fact that the net energy system evaluates roughages much lower than the TDN system of feed evaluation.

These data indicate that cattle receiving high-roughage rations attempted to satisfy their nutrient and energy requirements for growth and maintenance by consuming more total feed. Furthermore, there seems to be a limit to the amount of grain calves will consume, even when the roughage is restricted, as indicated by reduced feed consumption on the 80:20 C:R ratio in two of the three trials. With the exception of the second trial, the increase in daily intake of concentrates was not proportional to the increase in concentrate in the ration between the 65:35 and 80:20 ratios. Dowe et al. (1955) observed that increasing the proportion of concentrates above a 2:1 C:R ratio did not result in a proportional increase in concentrate intake in all cases.

The age of the cattle may have a bearing on the daily intake of concentrates as well as total feed consumption. Keith et al.

(1952) found that yearling steers appeared to have the ability to consume and utilize higher levels of concentrates than steer calves. This was shown by the fact that daily feed intake of steer calves declined markedly when the level of concentrates exceeded a 2:1 C:R ratio; whereas, daily feed intake of yearling steers was maintained at a rather high level even on a 3:1 C:R ratio.

Effect of C:R Ratio on Feed Efficiency

Feed efficiency values are presented in Table V, with a comparison of TDN and net energy as measures of efficiency of feed use. Using pounds of feed per pound of gain as the measure of efficiency, it can be seen that in each trial the greatest efficiency was obtained on the 80:20 C:R ratio, with the exception of the heifers in Trial II. In that trial, heifers on the 65:35 C:R ratio exhibited the greatest feed efficiency. According to the feed per pound of gain method of measurement, feed efficiency tended to increase as the proportion of roughage in the ration decreased. These results are in agreement with those reported by other workers. Differences between ratios were significant ($P < .01$) only in the third trial, however. Using Duncan's multiple range test and analysis of variance, it was found that the rations ranked as follows in order of efficiency: 80:20, 65:35, 50:50 and 35:65. Differences between rations were significant except between the 65:35 and 50:50 C:R ratios.

Using estimated TDN as a measure of efficiency of feed utilization, a great deal of variation between trials will be observed from the results shown. In general, there was a tendency for the

TABLE V POUNDS OF FEED, TDN AND NET ENERGY CONSUMED PER POUND OF GAIN BY STEERS AND HEIFERS ON DIFFERENT C:R RATIOS[1]

Sex	Steers				Heifers			
C:R Ratio	35:65	50:50	65:35	80:20	35:65	50:50	65:35	80:20
Trial I								
Concentrate	-----	5.07	6.85	6.46	-----	5.53	6.71	8.03
Roughage	-----	5.07	3.69	1.62	-----	5.53	3.61	2.01
Total	-----	10.14	10.54	8.08	-----	11.06	10.32	10.04
TDN	-----	6.24	7.00	5.76	-----	6.81	6.86	7.16
Net energy	-----	5.65	6.53	5.50	-----	6.16	6.40	6.84
Trial II								
Concentrate	3.96	5.82	7.29	8.38	4.43	6.52	7.07	9.76
Roughage	7.36	5.82	3.93	2.09	8.22	6.52	3.81	2.44
Total	11.32	11.64	11.22	10.47	12.65	13.04	10.88	12.20
TDN	6.30	7.02	7.31	7.31	7.05	7.87	7.09	8.51
Net energy	5.55	6.42	6.89	7.08	6.20	7.20	6.69	8.24
Trial III								
Concentrate	3.86	5.21	6.86	7.19	4.24	5.47	6.95	8.02
Roughage	7.18	5.21	3.69	1.80	7.86	5.47	3.75	2.01
Total	11.04	10.42	10.55	8.99	12.10	10.94	10.70	10.03
TDN	6.25	6.39	6.97	6.37	6.85	6.71	7.07	7.10
Net energy	5.42	5.76	6.49	6.08	5.94	6.04	6.58	6.78

[1]Feed efficiency values were calculated from feed consumption and gain prior to first shipment of cattle. TDN and net energy were calculated using TDN and net energy values of Morrison (1956).

pounds of TDN per pound of gain to increase as the ratio of C:R in the ration increased. Differences between treatments were statistically significant ($P < .05$) only in the third trial, however. In that trial, a significantly greater amount was needed on the 65:35 ratio than on the other rations. Also, calves fed the 80:20 mixture required significantly more TDN per pound of gain than those fed the 35:65 or 50:50 ratios.

Estimated net energy per pound of gain followed the same pattern as TDN. No significant differences between treatments were obtained in the first trial. However, significant differences ($P < .01$) were obtained in the second trial, with the smallest amount of net energy needed on the 35:65 ratio, and the greatest amount required on the 80:20 ratio. There was no significant difference between the 50:50 and 65:35 C:R ratios in net energy per unit of gain. In the third trial, net energy per pound of gain was significantly greater ($P < .01$) for the 65:35 and 80:20 ratios than for the 35:65 and 50:50 mixtures.

A comparison of TDN and net energy required per pound of gain shows that the differences in efficiency between ratios are greater with the net energy system than when the TDN system is used to measure efficiency. When the two systems are compared with amount of feed required per pound of gain, it is seen that there is an inverse relationship between either TDN or net energy and pounds of feed per pound of gain. Apparently calves of this age are capable of utilizing TDN from roughage as efficiently as from concentrates.

Effect of C:R Ratio on Time Required to Reach Market Grade

The average length of time required for cattle on the different ratios to attain the desired slaughter grade is presented in Table VI. It would be expected that cattle fed the higher concentrate rations would reach market grade more rapidly than those on the low concentrate rations. However, this was not true in all trials. It can be seen from the table that there were no consistent differences among treatments with steers in the three trials. However, an average of Trials II and III shows that steers fed the 35:65 ratio required a somewhat longer feeding period than those on the higher concentrate rations. In contrast, heifers required a longer feeding period on the 80:20 C:R ratio and reached market grade more rapidly on the 50:50 mixture. Some error can be attributed to inability of the committee to determine when the animals were ready for market, and to within pen variations of animals. However, carcass grades were quite uniform in each trial.

TABLE VI AVERAGE NUMBER OF DAYS REQUIRED FOR STEERS AND HEIFERS ON DIFFERENT C:R RATIOS TO REACH MARKET GRADE[1]

Sex	Steers				Heifers			
C:R Ratio	35:65	50:50	65:35	80:20	35:65	50:50	65:35	80:20
Trial I	---	173	172	170	---	173	171	174
Trial II	170	156	165	150	167	155	156	169
Trial III	177	174	166	179	169	158	170	171
Average[2]	174	165	166	165	168	157	163	170

[1]Calves were removed from treatment individually when they reached an estimated slaughter grade of high-good to low-choice.

[2]Only Trials II and III were averaged together since Trial I contained only three treatments.

Effect of C:R Ratio on Carcass Merit

From Table VII it can be seen that there was very little apparent difference in dressing percent of steers or heifers on the different ratios. However, greater differences between treatments might have been obtained if the cattle had been fed to a higher grade. Analysis of variance showed no significant differences between treatments in any of the three trials in spite of the rather large differences in the third trial. An average of Trials II and III shows a somewhat lower dressing percent for both steers and heifers on the 35:65 ratio; however, there was no consistent trend for improvement in dressing percent as the proportion of concentrate was increased above the 50:50 ratio. These data are in contrast with results obtained by Richardson et al. (1956), who found that

TABLE VII DRESSING PERCENT OF STEERS AND HEIFERS ON DIFFERENT C:R RATIOS[1]

Sex	Steers				Heifers			
C:R Ratio	35:65	50:50	65:35	80:20	35:65	50:50	65:35	80:20
Trial I	-----	61.76	61.66	61.00	-----	61.28	61.70	61.37
Trial II	59.30	59.60	59.10	60.00	59.40	59.70	59.40	60.90
Trial III	57.40	63.00	60.00	57.86	57.86	59.44	58.53	58.69
Average[2]	58.35	61.30	59.55	58.93	58.63	59.57	58.96	59.80

[1]Calculated from hot carcass weight minus 2.5% shrink, based on final live weight at Ft. Reno.

[2]Only Trials II and III were included in the average since Trial I consisted of only three C:R ratios.

steer and heifer calves fed the high roughage (1:1) ration had a lower dressing percent than those on the higher concentrate rations. They also found that yield tended to improve as the proportion of grain in the ration increased.

As shown in Table VIII, differences in carcass grade between treatments for steers and heifers were also very small. This is to be expected since the cattle were removed from experiment individually and slaughtered as they reached an estimated slaughter grade of high-good to low-choice. Thus, differences in carcass grade should have been small if selection on the basis of live grade was accurate. These data indicate that although a longer feeding period may be required, desirable carcasses can be produced on high roughage rations. In comparison to cattle fattened in commercial feedlots, the cattle in these trials were slaughtered at relatively low grades.

TABLE VIII AVERAGE U.S. CARCASS GRADES OF STEERS AND HEIFERS ON DIFFERENT C:R RATIOS[1]

Sex	Steers				Heifers			
C:R Ratio	35:65	50:50	65:35	80:20	35:65	50:50	65:35	80:20
Trial I	---	5.9	6.3	5.8	---	5.1	5.4	6.0
Trial II	5.7	6.1	6.2	6.2	5.9	5.7	6.2	5.4
Trial III	6.1	5.7	6.0	6.0	5.1	5.1	5.3	5.0
Average[2]	5.9	5.9	6.1	6.1	5.5	5.4	5.8	5.2

[1]Carcass grades are based on a numerical scoring system in which Prime = 1, Good = 7 and Standard = 10.

[2]Only Trials II and III were included in the average since Trial I consisted of only three C:R ratios.

As will be observed from Table IX, there were no consistent differences in marbling scores between the various ratios. In Trial II a higher degree of marbling was observed with steers and heifers fed the 80:20 C:R ratio while the other ratios were about equal. In the third trial, there was little difference in marbling scores of heifers; however, steers on the 35:65 ratio had somewhat less marbling than those on the other ratios. There were no significant differences in marbling scores between ratios in either trial, however.

TABLE IX AVERAGE MARBLING SCORES OF STEERS AND HEIFERS ON DIFFERENT C:R RATIOS[1]

Sex	Steers				Heifers			
C:R Ratio	35:65	50:50	65:35	80:20	35:65	50:50	65:35	80:20
Trial II[2]	7	6	7	4	6	7	7	4
Trial III	10	8	9	9	6	6	7	7
Average	8.4	7.0	8.0	6.5	6.1	6.2	7.0	5.4

[1]Marbling scores were not available for Trial I.

[2]Marbling score values are as follows: Abundant = 1, moderate = 8 and slight to none = 13.

Results show that there was little effect of C:R ratio upon carcass merit of steers and heifers in these trials. However, there was a tendency for steers fed the 35:65 ratio to fatten more slowly than those on the other rations. This was evidenced by the fact that although daily gains were comparable to those of calves on the higher concentrate rations, a slightly longer feeding period was required. Much of the gain in weight by calves on this ration may

have been in the form of growth rather than fat. Furthermore, had older cattle been used, greater differences in carcass quality between C:R ratios might have been observed.

Effect of C:R Ratio on Economic Aspects

As shown in Table X, there was a negative return from cattle on all rations in the first two trials. The failure to make a profit was due mainly to high costs of feed and relatively poor gains. Net returns in the third trial were very satisfactory on all rations since gains were good, feed prices were low and the price of beef was high at the time the cattle were sold.

In Trial I, it can be seen that steers made the smallest economic loss on the 80:20 ratio with returns on the other rations being about equal. A reverse trend was obtained from heifers in this trial, with the least amount of financial loss occurring on the 50:50 ratio, and the magnitude of loss increasing as the C:R ratio widened.

It is apparent from the average of Trials II and III that the smallest returns were obtained from steers and heifers on the 65:35 ratio. There was very little difference in net return, within sex, between the other rations. In contrast, Keith et al. (1952) concluded that the most economical ratio to feed to steer calves for average feed price relationships will range between a 2:1 and 1:2 ratio of concentrate-to-alfalfa hay. The reason for the lower returns from calves fed the 65:35 ratio is not apparent.

Results of these three trials show that economic returns follow about the same pattern as rate of gain. It has been shown that

TABLE X NET RETURN PER CALF FROM STEERS AND HEIFERS ON DIFFERENT C:R RATIOS ($)[1]

Sex	Steers				Heifers			
C:R Ratio	35:65	50:50	65:35	80:20	35:65	50:50	65:35	80:20
Trial I	-----	-14.30	-14.27	-12.82	-----	- 1.95	- 3.41	- 8.54
Trial II	-10.75	-17.85	-20.54	-13.43	- 5.40	- 6.60	-13.58	- 7.83
Trial III	45.82	49.01	40.94	46.80	52.21	54.41	47.22	49.89
Average[2]	17.54	15.58	10.20	16.69	23.40	23.90	16.82	21.03

[1]Net returns were calculated by subtracting the cost per animal and feed cost from the market value per calf. Market value was calculated from carcass grade, yield and value of dressed beef, and based on final weights at Ft. Reno.

[2]Trial I was not included in the average.

there was very little difference in carcass yield and grade of steers and heifers on the different rations. Although the unit cost of feed was lower on the higher roughage rations, cost of gain was about equal for all rations due to differences in amount of feed required per unit of gain. The cost of handling and processing feed was not included in these trials; however, it is of importance to the commercial feeder.

Steers vs. Heifers

Results of the comparison of steers and heifers are similar to those obtained by Loeffel (1953) and Langford and Douglas (1956), who found that steers made more rapid gains and were more efficient in feed conversion than heifers. In each trial, rate of gain and feed intake were greater for steers than heifers. Although there were no statistically significant differences in daily feed intake, the difference in rate of gain was significant in each trial, as shown in the analysis of variance in Appendix Table XIV. Steers were more efficient in feed conversion in each trial, whether efficiency was expressed as pounds of feed, pounds of TDN, or therms of net energy per pound of gain. However, these differences were not significant in Trial I. In Trial II, there was a significant difference ($P < .05$) between sexes in pounds of feed and TDN per pound of gain, but no significant difference was obtained in net energy required per unit of gain. In the third trial, a significant difference ($P < .01$) was observed in both TDN and net energy, as well as pounds of feed per pound of gain ($P < .01$).

Carcass data showed that heifers were generally fatter and graded higher in the carcass than steers; therefore, they probably

could have been removed from experiment earlier. This would tend to indicate that the accuracy of live animal evaluation was not equal for the two sexes. Very little difference in carcass yield was observed in any trial. Heifers in Trials II and III had more marbling than steers; however, the difference was significant ($P < .01$) only in the third trial.

From the average of the three trials in Table XI, it was found that steers gained approximately 15 percent faster on about 10 percent less feed per pound of gain and consumed five percent more feed per day than heifers. Although heifers graded higher and had a higher degree of marbling, there was very little difference between the sexes in carcass yield and time required to reach market grade. Again, indications are that heifers could have been removed from experiment earlier. The carcass data are in disagreement with results obtained by Dyer and Weaver (1955) who found that when steers and heifers were fattened to the same slaughter grade, heifers tended to reach market grade sooner than steers. Also, they found that heifers yielded 1.8 percent higher in the carcass due to higher condition.

Net returns per calf over the three year period were considerably greater for heifers in spite of the fact that steers were more efficient in feed conversion. This difference in return was due to the fact that the "on-foot" values of steers and heifers were about the same, while the initial cost of heifers was considerably less than that of steers.

Steers produced about equal gains on all rations tested; whereas, heifers consistently made the best gains on the 50:50 ratio and

TABLE XI COMPARISON OF THE PERFORMANCE OF STEERS AND HEIFERS IN ALL TRIALS

	Steers	Heifers
Average weights (lb)		
Initial	550	514
Gain to market	320	269
Ave. daily gain	1.90	1.62
Ave. daily feed intake (lb)	20.19	19.10
Feed efficiency values[1]		
Concentrates	5.35	5.98
Roughage	3.88	4.27
Total	9.23	10.25
TDN	6.52	7.07
Net energy	6.02	6.54
Average days on feed	169	167
Marketing data		
Dressing %	60.18	59.99
Ave. carcass grade	Gd.+	Ch.-
Marbling score[2]	7.4	6.1
On-foot value/cwt. ($)	21.78	21.86
Net return/calf ($)	5.40	12.65

[1]Efficiency values are based on pounds of feed and TDN, and therms of net energy per pound of gain.

[2]Only Trials II and III are included in the marbling score.

poorest gains on the 80:20 mixture. These differences were not significant, however. Therefore, according to these results, there seems to be no great difference between steers and heifers in ability to utilize the various ratios of C:R tested.

Effect of Pelleting A Roughage Mixture

Shown in Table XII are results of the trial involving the use of a pelleted roughage mixture composed of equal parts of alfalfa hay and cottonseed hulls. Contrary to results obtained by Webb and Cmarik (1957), daily gains and feed efficiency were lower on the pelleted roughage when it was fed either free-choice or in equal amounts. There was no appreciable difference in feed consumption, as affected by the form in which the roughage was fed. However, the four calves used in the palatability test exhibited a preference for the pelleted roughage by consuming an average of 9.5 pounds of the pelleted roughage and only 4.3 pounds of the chopped roughage per day.

During the early part of the experiment, some difficulty was encountered in getting the calves receiving the free-choice roughage to eat all of the grain-protein supplement mixture. This problem was corrected by adding a small amount of molasses to the concentrate mixture of all lots. The fact that the cattle receiving the pellets ate considerably more feed daily in the first part of the test than those on the ground roughage probably accounts for the difficulty in getting them to consume all of the concentrate mixture.

TABLE XII EFFECT OF PELLETING AN ALFALFA HAY-COTTONSEED HULLS ROUGHAGE MIXTURE FOR BEEF CALVES

Feeding system	Free-choice		Controlled	
Lot number	1	2	3	4
Roughage form	Pelleted	Chopped	Pelleted	Chopped
Number of calves/lot	6	6	6	6
Days on feed	108	108	108	108
Average weights (lb)				
Initial 11-8-57	410	405	410	413
Final 2-24-58	589	613	578	592
Total gain	178	207	168	178
Ave. daily gain	1.65	1.92	1.56	1.65
Ave. daily feed intake (lb)				
Roughage	15.3	15.1	11.2	11.2
Concentrate[1]	3.7	3.7	3.7	3.7
Total	19.0	18.8	14.9	14.9
Feed per cwt. gain (lb)	1155	983	956	902
Feed cost/cwt. gain ($)[2]	19.63	13.58	16.85	13.19

[1]A concentrate mixture composed of 2.0 pounds ground milo and 1.7 pounds cottonseed meal per head daily was fed to all lots.

[2]An additional cost of $6.00 per ton for pelleting the roughage fed to lots one and three was used in calculating feed costs per cwt. gain.

Cost of gain was considerably greater with calves fed the pelleted roughage, due mainly to the extra cost of pelleting. Under the conditions of this trial it was not economical to pellet the roughage mixture. These results disagree with those obtained by Webb and Cmarik (1957), whereby feed intake and rate of gain were increased by pelleting alfalfa hay or a timothy-alfalfa hay mixture. Probably the kind and quality of roughage used accounts for some of the differences in results between this test and others with pelleted roughage mixtures.

Effect of Pelleting A Ration Containing An 80:20 C:R Ratio

In the three previous fattening trials in which an 80:20 ratio was fed in the ground form, feed consumption was low. Therefore, this experiment was conducted primarily to determine if daily feed intake could be improved by pelleting the ration. Results of this experiment involving the use of a pelleted fattening ration containing a C:R ratio of 80:20 are shown in Table XIII. Average daily gains in this trial were low, presumably due to low feed intake and the fleshy condition of the calves at the start of the trial.

The results show that rate of gain and daily feed intake were lower on the pelleted ration, the difference in feed intake being statistically significant ($P < .01$). However, efficiency of feed conversion was significantly greater ($P < .01$) on the pelleted ration. Feed cost per pound of gain was considerably less on the pelleted ration even though an additional cost of $6.00 per ton was included. Average dressing percent of cattle on the pelleted ration was 1.4 percent less than for the control cattle. Carcass grades

TABLE XIII COMPARISON OF A PELLETED vs. A CHOPPED RATION FOR FATTENING BEEF CALVES

Form	Chopped	Pelleted
Lot number	1	2
Number of calves/lot	12	12
Days on feed	110	110
Average weights (lb)		
Initial 3-10-58	622	623
Final 6-21-58	784	771
Gain to market	162	148
Ave. daily gain	1.47	1.35
Ave. daily feed intake (lb)		
Roughage	3.34	2.53
Concentrate	13.37	10.14
Total	16.71	12.67
Feed/cwt. gain (lb)	1142	945
Feed cost/cwt. gain ($)[1]	22.80	20.32
Marketing data		
Ave. yield (%)	60.00	58.60
Ave. carcass grade[2]	3.00	3.10
On-foot value/cwt. ($)[3]	29.18	26.06
Net return/calf ($)[4]	42.56	23.97

[1]A cost of $6.00 per ton for pelleting was included in determining the cost of the pelleted ration.

[2]Carcass grades are based on the values: Prime = 1, Good = 4 and Standard = 10.

[3]On-foot value was computed from carcass value according to grade and yield, and based on final live weight at Ft. Reno.

[4]Net return/calf was calculated from market value per calf minus cost of calf and feed.

were essentially equal on both rations, however. Financial results show that feed efficiency was greater and cost of gain lower on the pelleted ration. However, net return per calf was less due to smaller gains and lower carcass yield.

There was no evidence of rumen disturbance among calves fed the pelleted ration at the time of slaughter, as reported by Jensen et al. (1958). These workers observed that lambs fattened on pelleted feed showed significantly more ruminal parakeratosis at the time of slaughter than lambs fattened on the same feed ingredients in the loose form.

Results of this trial agree with those obtained by Baker et al. (1954) who found that rate of gain, carcass grade and dressing percent were lower with heifers fed a complete, pelleted ration than with those receiving the same ration in meal form. Heifers fed the pelleted ration consumed less feed, but had equally as good feed conversion as the more rapidly gaining control animals. A similar test by these authors (1957) showed that feeding a small amount of long alfalfa hay to the heifers on the pelleted ration improved rate of gain, feed efficiency, rumination and the general feedlot performance. Also, Thomas et al. (1958) obtained increased gains from yearling steers on a complete, pelleted ration by feeding straw free-choice.

When data from this test and other similar experiments are compared, it is found that feed efficiency is generally greater and feed consumption is lower when pelleted rations are fed. According to Forbes et al. (1928) and Mitchel et al. (1932), the efficiency of energy utilization decreases as feed intake increases. Therefore, the greater feed efficiency with pelleted rations may have been due

to reduced feed intake, rather than improvement in nutritive value of the rations.

Statistical Discussion

In the statistical analysis of many animal experiments, the animal variation within pens is used as the error term for testing the other variances. There has been some doubt as to the accuracy of this term, in that it may not be an accurate measure of the true experimental error. Therefore, if this value is smaller than the real experimental error, significance would be obtained too often.

A comparison was made, in the first three trials, between the mean squares of "within pen" variation and "between pens treated alike" variation of rate of gain, to determine if there was any variation associated with pens. It was necessary to multiply the "between pens treated alike" or error mean square by the average number of animals per pen to get both values on an individual animal basis, so that a comparison could be made. In Trials I and III the average number of calves per pen resulted in fractions of numbers due to missing items.

As shown in Appendix Table XIV, there was little difference between the two values in any of the trials; the largest difference being in Trial I. The "within pen" mean squares were 62.8 percent, 96.8 percent and 104.8 percent of the "between pens treated alike" mean squares for Trials I, II and III, respectively. Although the difference between the two values was not excessively large in any one trial, the fact that the "between pens treated alike" values were larger in two of the three trials indicates that some variation was probably associated with pen.

SUMMARY

Three trials, involving 236 long-aged steer and heifer calves, were conducted to study the effects of various ratios of C:R on the feedlot performance and carcass merit of beef calves. Concentrate:roughage ratios of 50:50, 65:35 and 80:20 were tested in the first trial; whereas, in two subsequent trials a 35:65 ratio was also included. Ground milo, cottonseed meal and molasses were the concentrates fed while equal parts of alfalfa hay and cottonseed hulls constituted the roughage. Digestible protein, calcium and phosphorus contents were equalized in all rations. A comparison was made between steers and heifers on each ration. The cattle were removed from experiment individually at a slaughter grade of high-good to low-choice. Two additional trials, using 28 steer and heifer calves, were conducted to study the effects of pelleting a roughage mixture and a fattening ration.

There were no significant differences in rate of gain of steers or heifers due to treatment; however, heifers consistently made the most rapid gains on the 50:50 ratio. Feed intake increased as the proportion of roughage in the ration increased. No significant difference in TDN per pound of gain or carcass grade was observed between C:R ratios tested. A greater length of time on feed was required by steers fed the 35:65 ratio and for heifers on the 80:20 mixture. Steers made 15 percent faster gains, consumed five percent

more feed, and were 10 percent more efficient in feed conversion than heifers. There was no appreciable difference between steers and heifers in time required to reach the desired slaughter grade. However, heifers had a higher degree of marbling and graded higher in the carcass than steers.

Pelleting a mixture of cottonseed hulls and alfalfa hay decreased gain and feed efficiency slightly. There was no improvement in rate of gain or feed intake from pelleting a fattening ration containing an 80:20 C:R ratio. However, feed efficiency was higher and feed cost per cwt. gain lower on the pelleted ration.

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A P P E N D I X

TABLE XIV ANALYSES OF VARIANCES OF RATE OF GAIN FOR STEERS AND HEIFERS ON DIFFERENT C:R RATIOS

Trial Number	Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F Value
I	Between pens unweighted means	11	.7174		
	Treatment	2	.0474	.0237	.66
	Sex	1	.4391	.4391	12.30**
	Treatment X sex	2	.0170	.0085	.24
	Error	6	.2139	.0357	
	Within pen	47	5.1856	.1103	
	Between pens (Error M.S. X 4.92)			.1756	
II	Between pens unweighted means	15	.5871		
	Treatment	3	.0301	.0100	.39
	Sex	1	.2732	.2732	10.59*
	Treatment X sex	3	.0776	.0259	1.00
	Error	8	.2062	.0258	
	Within pen	64	7.9927	.1249	
	Between pens (Error M.S. X 5)			.1290	
III	Between pens unweighted means	23	.5489		
	Treatment	3	.0276	.0092	.65
	Sex	1	.2440	.2440	17.31**
	Treatment X sex	3	.0524	.0175	1.24
	Error	16	.2249	.0141	
	Within pen	69	3.9522	.0573	
	Between pens (Error M.S. X 3.88)			.0547	

* Significant at the 5 percent level.

** Significant at the 1 percent level.

TABLE XV FEED PRICES USED IN CALCULATING FEED COST PER CWT. GAIN ($)[1]

Trial	I	II	III[2]
Milo	41.00	50.00	40.00
Cottonseed meal	63.00	66.00	62.00
Molasses	40.00	60.00	54.00
Alfalfa hay	25.00	30.00	25.00
Cottonseed hulls	18.00	22.50	18.00
Ground limestone	15.00	15.00	16.00

[1]Price values are on a per ton basis.

[2]These values were also used for the pelleting trials.

TABLE XVI VALUES PER CWT. FOR THE CARCASS GRADES OF BEEF USED IN CALCULATING ON-FOOT VALUES

Trial	I[1]	II	III	Pellet
Carcass grades:				
High-choice	-----	35.50	46.50	46.50
Average-choice	34.00	34.50	46.00	46.00
Low-choice	32.65	33.65	45.50	45.50
High-good	31.30	32.60	45.00	44.50
Average-good	30.00	31.75	44.50	43.75
Low-good	28.65	30.90	44.00	43.00
High-standard	27.30	29.90	43.50	-----
Average-standard	-----	29.00	-----	-----

[1]The values in this trial are for steers. Values of heifer carcasses varied as follows: 3 percent lower for average-choice and high-choice, 2 percent lower for high-good and average-good, 1 percent lower for low-good and high-standard.

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