Effect of barley preparation and roughage level upon the performance of fattening steers
by Lyle Leslie Myers

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE in ANIMAL SCIENCE
Montana State University

Abstract:
Yearling Hereford steers were fed steam-rolled and dry-rolled barley with varying levels of hay and two pounds of a protein supplement per head daily in two similar fattening experiments (trials I and II).

Hereford calves were fed steam-rolled barley, steam-rolled barley with molasses, and dry-rolled barley during a wintering experiment and a fattening experiment. All steers received hay and a protein supplement.

The weight gain of steers sired by performance tested bulls was compared with steers sired by untested bulls.

Steers fed steam-rolled barley or dry-rolled barley plus two pounds of hay had the same average daily gain during trial I; however, steers fed day-rolled barley gained slightly faster during trial II= Feed consumption and feed efficiency were about the same for steers fed steam-rolled and day-rolled barley= Het return favored the steers that received day-rolled barley= The performance of steers fed steam-rolled barley plus molasses was similar to the performance of steers that received steam-rolled or day-rolled barley= Steers fed an all-concentrate ration consumed less feed and were more efficient than steers that received barley and hay= Average daily gain, carcass grades, and net returns were about the same for steers fed an allconcentrate ration and steers fed barley plus two pounds of hay per head daily= Steers fed five or six pounds of hay per head daily did not perform as well as steers that received two pounds of hay or no hay= There was a significant difference ($P<0.05$) in average daily gain between steers fed six pounds of hay and steers fed two pounds of hay per animal daily= The steers fed five or six pounds of hey daily consumed more feed, were less efficient, and had a lower net return than steers fed lower levels of hay= The average daily gain of steers sired by performance tested bulls was significantly greater ($P<0.0l$) than the gain of steers sired by untested bulls = These experiments indicated that: (l) method of barley preparation did not significantly affect the performance of fattening steers, (2) there was little difference in performance of steers fed an all-concentrate ration versus steers fed a full feed of barley plus two pounds of hay, (3) steers fed five or six pounds of hay did not perform as well as steers that received lower levels of hay, and (4) steers sired by performance tested bulls gained significantly faster than steers sired by untested bulls =

EFFECT OF BARLEY PREPARATION AND ROUGHAGE LEVEL UPON THE PERFORMANCE OF FATTENING STEERS

by

LYLE LESLIE MYERS

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree

of

MASTER OF SCIENCE

in

ANIMAL SCIENCE

Approved:

Fred S. Willson
Head, Major Department

Oscar O. Thomas
Chairman, Examining Committee

Leon D. Thomas
Dean, Graduate Division

MONTANA STATE COLLEGE
Bozeman, Montana

August, 1962

ACKNOWLEDGMENTS

I express thanks to Dr. O. O. Thomas for his guidance in conducting the research work and in the writing of this thesis. His help during my graduate study is also appreciated. Thanks is give to Dr. D. W. Blackmore and Dr. Kenneth Goering for their suggestions in the preparation of this manuscript and to Dr. Ervin P. Smith for his help with the statistical analysis. Appreciation is also expressed to Gary L. Cowman, a fellow graduate student, who helped in the collection of the experimental data.

I am especially grateful to my wife, Patricia, who made this work possible through her sacrifices, work, and encouragement.

I am thankful for my parents, Mr. and Mrs. James E. Myers, who were instrumental in the advancement of my education.

Thanks is given to Don Tavenner, Deer Lodge, Montana, who supplied the certified steers used in two of the experiments and to the Peter Hand Foundation for furnishing Cellu-ade.

TABLE OF CONTENTS

INDEX TO THE TABLES

Table | Page

INDEX TO THE FIGURES

INDEX TO THE APPENDIX

Appendix Table — Page

ABSTRACT

Yearling Hereford steers were fed steam-rolled and dry-rolled barley with varying levels of hay and two pounds of a protein supplement per head daily in two similar fattening experiments (trials I and II).

Hereford calves were fed steam-rolled barley, steam-rolled barley with molasses, and dry-rolled barley during a wintering experiment and a fattening experiment. All steers received hay and a protein supplement. The weight gain of steers sired by performance tested bulls was compared with steers sired by untested bulls.

Steers fed steam-rolled barley or dry-rolled barley plus two pounds of hay had the same average daily gain during trial I; however, steers fed dry-rolled barley gained slightly faster during trial II. Feed consumption and feed efficiency were about the same for steers fed steam-rolled and dry-rolled barley. Net return favored the steers that received dry-rolled barley. The performance of steers fed steam-rolled barley plus molasses was similar to the performance of steers that received steam-rolled or dry-rolled barley.

Steers fed an all-concentrate ration consumed less feed and were more efficient than steers that received barley and hay. Average daily gain, carcass grades, and net returns were about the same for steers fed an all-concentrate ration and steers fed barley plus two pounds of hay per head daily.

Steers fed five or six pounds of hay per head daily did not perform as well as steers that received two pounds of hay or no hay. There was a significant difference ($P<0.05$) in average daily gain between steers fed six pounds of hay and steers fed two pounds of hay per animal daily. The steers fed five or six pounds of hay daily consumed more feed, were less efficient, and had a lower net return than steers fed lower levels of hay.

The average daily gain of steers sired by performance tested bulls was significantly greater ($P<0.01$) than the gain of steers sired by untested bulls.

These experiments indicated that: (1) method of barley preparation did not significantly affect the performance of fattening steers, (2) there was little difference in performance of steers fed an all-concentrate ration versus steers fed a full feed of barley plus two pounds of hay, (3) steers fed five or six pounds of hay did not perform as well as steers that received lower levels of hay, and (4) steers sired by performance tested bulls gained significantly faster than steers sired by untested bulls.

INTRODUCTION

The fattening of beef cattle is increasing in importance in Montana. These cattle supply distant markets located in high population areas as well as local markets. The feedlot operator must buy high quality cattle at a reasonable price and follow good nutrition practices if he is to compete effectively on the market. Steers sired by Individual Performance Record (IPR) bulls are preferred by many cattle feeders. These steers often gain faster than steers from untested sires.

There is an abundance of barley and hay produced in Montana and much of it is used locally for the fattening of beef cattle. Because barley is commonly prepared in several physical forms, it is important to evaluate these forms as to their relative fattening value.

The level of hay to use in the ration is an important consideration when fattening cattle, because it directly affects the energy value of the ration. Early workers concluded that hay was necessary in the ration of the ruminant. More recent investigation has tended to disprove this belief. It would seem that present day investigations should be designed to study the fattening value of rations with varying levels of hay and to learn more about feed preparation.

REVIEW OF LITERATURE

Ruminant Digestion

The ruminant, or cud-chewing animal, is a herbivore with a digestive system especially adapted for efficient utilization of roughage. The rumen and reticulum provide a favorable environment for bacteria and protozoa which are important in the digestion of cellulose (Rogers, 1958). The microorganisms can also assimilate non-protein nitrogen (NPN) with the subsequent formation of protein (Phillipson, 1960). Rumen microorganisms decompose the plant materials in the rumen into short-chained fatty acids, principally acetic acid (Rogers, 1958). Ruminants can synthesize vitamin K and most of the B vitamins, including thiamine, riboflavin, niacin, pyridoxine, pantothenic acid, biotin, folic acid, and B_{12} (Agarwala, 1958).

Carbohydrates. Cellulose digestion is carried out mostly by iodophilic bacteria with the production of volatile fatty acids (VFA's) and gases (Agarwala, 1958). Annison and Lewis (1959) suggested that a series of enzymes are involved in the hydrolysis of cellulose. Cellulases of the bacterial cell cause the formation of eroded areas of cellulolytic material. These eroded areas make it possible for the bacteria to further degrade cellulose material.

There are many factors that can affect the rate and degree of cellulose digestion. According to MacLeod and Murray (1956), a combination of valine, leucine, and isoleucine is responsible for a strong stimulation of cellulose digestion. Annison and Lewis (1959) stated that, if a more readily fermentable carbohydrate such as starch is added to the ration, the degree of digestibility of dietary cellulose is reduced. Increasing

the total nitrogen in the ration above one percent did not affect the digestion of cellulose. The extent of cellulose digestion is also affected by the age of the plant and the degree of lignification of the plant fiber (Phillipson, 1960).

Starch is fermented in the rumen with the production of volatile and non-volatile fatty acids. Starch digestion differs from cellulose digestion as the rumen is not essential for starch utilization. Starch is readily depolymerized to glucose by the action of the digestive secretions of the small intestine and is readily absorbed in the small intestine. The fermentation of starch in the rumen is a slow and complex process accompanied by multiplication of the microorganisms concerned. The utilization of starch in the rumen is important in the maintenance of a flourishing rumen flora (Annison and Lewis, 1959).

Proteins. During the first six hours after feeding, the predominant phenomenon occurring in the ruminant is the rapid digestion of proteins (Hale et al., 1947). Blaizot and Raynaird, in 1957, identified 17 amino acids in the rumen of cattle 24 hours after a feed of lucerne hay. This amount was less than was in the feed. However, it was concluded that amino acids were produced by microorganisms.

A ration may contain nitrogen in two forms: protein nitrogen or non-protein nitrogen (NPN). Experiments have shown that urea and other NPN sources in rations containing a small percentage of protein can be used by ruminants to supply a part of the dietary protein requirement. Microbial proteins may be metabolized from either dietary proteins or NPN. Microbial

protein and dietary protein are attacked enzymatically in the abomasum and small intestine and are absorbed as polypeptides and amino acids in the small intestine (Lewis, 1961). The conversion of NPN to protein is retarded after a level of 12 percent protein is reached in the diet (Agarwala, 1958).

One important factor influencing the fate of protein in the rumen is its solubility. With highly soluble material, there is considerable microbial degradation of protein with the production of ammonia. The ammonia diffuses into the blood stream and may be converted to urea in the liver and excreted. Some of the blood ammonia returns to the rumen via the saliva and may be resynthesized into microbial protein (Head, 1960). The microorganisms pass out of the rumen and are digested in the abomasum. Four-hundred four milligrams of dry microbial substance per 100 milliliters of liquor provide the animal with at least 180 grams of protein, 80 grams of carbohydrate, and 8 grams of ether extract daily (Thaysen, 1951).

Davis et al. (1957) have shown that the amounts of propionic, valeric, and butyric acids rose significantly with high (15 percent) protein intake. The percent of acetic acid decreased but the total amount of VFA production increased significantly when protein was increased.

Oyaert and Bouckaert (1961) conducted investigations of quantitative aspects of food digestion in the rumen. They found that losses of nitrogen were significantly reduced by the presence of starch in the rumen.

At low protein intakes, rumen ammonia production was low, but there was an increase in protein nitrogen in the rumen showing that the bacteria can use NPN for protein synthesis.

Vitamins. The adult ruminant does not require B vitamins in the diet, as these vitamins are synthesized by rumen microorganisms. Vitamin K is also synthesized in the rumen (Annison and Lewis, 1959). The reticulum is the major site of synthesis of thiamine, riboflavin, niacin, and pantothenic acid. Vitamin B_{12} is synthesized in the rumen and the caecum. All the other B vitamins are synthesized in the rumen. Absorption of B vitamins occurs through the wall of the abomasum and small intestine (Nutrition Reviews, 1956).

Thaysen (1951) stated that the chief organisms concerned in vitamin B synthesis are iodophilic cocci. A definite relationship exists between the population of these organisms and the amounts of proteins and polysaccharides synthesized.

According to Hollis et al. (1954), the type of roughage fed had a direct effect on the amount of B vitamins synthesized in the rumen. When a low quality roughage was fed, there was less synthesis of B vitamins. The addition of alfalfa ash to a ration containing a low quality roughage improved B vitamin synthesis.

The B vitamins, especially pyridoxine, are important in stimulating cellulose digestion (MacLeod and Murray, 1956).

Minerals. There are numerous functions of minerals in the body. These functions can be classified under four headings: (1) they contribute to the structure of the body, (2) they maintain the tissues against

the constant erosion of life processes, (3) they participate in the functional activities of the body, such as muscular activity, and (4) they are a part of the enzyme systems in the tissues (Mitchel, 1947).

Ruminant foodstuffs are usually comparatively rich in inorganic substances, especially the chlorides and phosphates of potassium and calcium (Annison and Lewis, 1959).

Soluble ingested minerals are absorbed from the rumen and from the other parts of the alimentary tract. Absorbed minerals in excess of body requirements are excreted in the urine. The large amount of saliva normally secreted by the ruminant is the major factor in the maintenance of the inorganic composition of the rumen contents (Annison and Lewis, 1959).

Volatile fatty acids. The amounts and proportions of volatile fatty acids produced by the ruminant depends on the type of diet, the time after feeding, and the age of the animal (Stewart et al., 1958). The main VFA's present in the rumen are butyric, propionic, and acetic acids. The proportions of VFA's in the rumen are butyric 15 percent, propionic 20 percent, and acetic acid 65 percent. Almost all dietary carbohydrate is absorbed from the rumen as volatile fatty acids.

According to Lewis (1961), the short-chained VFA's are produced by bacterial carbohydrate fermentation and bacterial metabolism of amino acids. The peak of VFA production is reached four to six hours after feeding. The digestion of cellulose yields more propionic acid and less acetic acid and butyric acid than the digestion of starch. In general, feedstuffs which are rapidly fermented in the rumen give rise to less

acetic acid. A probable explanation is the lowered rumen pH observed under these conditions which encourages the growth of organisms which produce propionic acid.

Investigations by Hibbs et al. (1956) showed that there was no effect of hay-grain ratio on the total VFA's in the rumen juice. Rumen pH increased with advancing age but was maintained at a lower level in the calves receiving the higher levels of concentrates.

Two cows and a bullock with rumen fistulae were studied for volatile fatty acid production at intervals after feeding (Emery et al., 1956). The specific acids studied were acetic, propionic, and butyric acids. On a roughage and a roughage-concentrate ration, the formation of acids increased for four hours and then slowly decreased to the end of a 24-hour period. On hay alone, more acetic acid and propionic acid and less butyric acid were produced than on a ration of grain and hay.

In a study by Krotkova et al. (1961), the effect of concentrates on the total VFA's in the rumen and on the pH of the urine was studied in the milk cow. With high levels of concentrates in the diet, there was a large volatile fatty acid accummulation in the rumen, but much of the VFA's were not used in the body. There was a shift to the acid side of the acid-base balance in the rumen beginning the first few days after a high concentrate diet was fed. There was also an increase in the acidity of the urine and blood. When the concentrate was decreased, these physiological balances became normal. Disorders of animal digestion coincided with the most extreme shifts of the acid-base equilibrium toward the acid side.

Acetic, propionic, and butyric acids are absorbed in substantial

amounts from the rumen of sheep. The rate at which VFA's leave the rumen is not proportional to the concentration of individual acids present in the blood. When equimolar solutions of VFA's are present in the rumen, the concentration in the blood leaving the rumen is in the following order: acetate> propionate> butyrate (Masson and Phillipson, 1951).

According to Pennington (1952), the absorption of VFA's from the rumen is probably a simple diffusion process. During the absorption of VFA's, there was appreciable utilization of acetic, propionic, and butyric acids by the rumen epithelium. Butyric acid was more readily utilized than acetic or propionic acids. The uptake of acetic and butyric acids was accompanied by some ketone body production, but propionic acid absorption was found to diminish the amount of ketone bodies produced by the tissues. It is not clear whether the nutritional requirements of the epithelium are supplied wholly or in part by the VFA's or by the blood (Annison and Lewis, 1959).

The caloric value of the VFA's depends on the amount of individual acids produced and their heat of combustion. As the digested calories increase in the ration, the VFA caloric value also increases, but at a diminishing rate. These acids account for approximately 60 percent of the energy requirement of the steer for maintenance (Stewart et al., 1958).

Stewart et al. (1958) conducted investigations with several common dairy feeds to study the production of VFA's. They found that fresh hand-clipped legume mixed grass caused a greater VFA production than did legume hay. The grass, however, markedly depressed acetic acid

production. Beet pulp significantly increased acetic acid production and corn meal increased propionic acid production. Urea increased VFA production.

Nutrient Requirements of Fattening Cattle

A steer fattening ration is most likely to be deficient in proteins, minerals, and vitamins. This is especially true when high concentrate rations are fed. The high daily gain reached in the feedlot places a stress on the fattening animal. Therefore, the ration must be adequate to meet the higher requirements of the animal.

Proteins. Protein is the principal constituent of the organs and soft structures of the animal body, and a liberal and continuous supply is needed in the diet of the animal throughout life (Maynard and Loosli, 1956). The amount of proteins, vitamins, and minerals needed for fattening cattle will depend chiefly upon the age of the animal. The nutrient requirements are much greater for young animals per 100 pounds of body weight than for those that are well grown when fattening begins. When immature animals are being fattened, there is considerable muscle growth or protein storage in the gain produced. More protein is needed for a young animal than for a mature animal that is storing more fat (Morrison, 1959). If fattening animals are fed a ration high in carbohydrate and fat and low in protein, they are likely to go "off feed." Morrison recommends that a ration for fattening should contain at least nine percent crude protein.

Hubbert et al. (1960) fed fattening beef cattle varying levels of protein on a 126-day fattening experiment. They found that steers fed

a 14 percent crude protein ration gained 11 percent faster than steers fed a ration that contained 10 percent crude protein. The steers fed the 14 percent crude protein ration required 5 percent less feed per unit of gain than the steers fed the 10 percent crude protein.

Klosterman et al. (1956) conducted experiments with fattening cattle to study the relationship between levels of protein, molasses, trace minerals, and quality of hay. There were highly significant differences in rate of gain of steers fed various amounts of protein. The amount of protein in the ration was of much greater importance when fed with poor quality timothy hay than with good quality mixed hay. It was concluded that there was little advantage in providing extra protein without added trace minerals. Molasses supplied the necessary trace minerals and also had a sparing effect on the protein requirement.

Vitamins. Vitamin A is of primary concern to cattle feeders who use high concentrate rations. Most cereal grains are low or lacking in vitamin A, whereas good quality roughages are often high in the vitamin.

Work at Purdue University by Beeson et al. (1961) was conducted to study levels of supplemental vitamin A required with and without alfalfa hay for fattening steer calves. Calves that received a ration without alfalfa hay showed a highly significant increase of 22 percent in average daily gain from an intake of 20,000 I. U. of vitamin A. Levels of vitamin A between 20,000 and 50,000 I. U. per head daily did not improve the performance of the steers. When cattle received a ration containing 10 percent sun-cured alfalfa pellets, there was little increase in daily gain when a vitamin A supplement was fed.

Hubbert et al. (1961) conducted an experiment with four lots of eight steers each to study the vitamin A requirement for feedlot cattle. The cattle were fed a control ration of 46 percent steam-rolled barley, 19 percent ground alfalfa, 19 percent Bermuda straw, 5 percent molasses, 10 percent cottonseed meal, and 1 percent urea. The ration contained 14 percent protein. The two treatments assigned the four groups of steers were a control ration and a control plus 20,000 I. U. of vitamin A daily. The cattle that received the vitamin A supplement gained 0.2 pounds more per steer daily, apparently because of an increased feed consumption. Feed efficiency was improved slightly in the steers fed the vitamin A supplement.

In a vitamin A study by Hale et al. (1961), feedlot steers were fed high levels of vitamin A. There was no vitamin A toxicity in steers fed 2,560,000 I. U. of vitamin A per head daily for 168 days. They found that most of the stored vitamin A was deposited in the liver, with some of the vitamin stored in the fat tissue only when the dietary level was very high. Ten thousand I. U. of vitamin A did not maintain liver stores in the cattle.

Minerals. It is important to provide an adequate mineral level in the rations of farm animals to insure a good appetite, a favorable feed efficiency, and a healthy animal (Mitchel, 1947). All the cereal grains are extremely low in calcium. High concentrate rations are very likely to be deficient in calcium. Usually the hays, either mixed or legume, will supply adequate calcium, but are low in phosphorus, ranging from 0.15 to 0.30 percent phosphorus (Morrison, 1959).

Hubbert et al. (1955) studied the importance of minerals for the cellulolytic rumen microorganisms. These investigators found that removal of each of the following minerals individually from the rumen media resulted in reduced cellulose digestion: sodium, potassium, phosphorus, magnesium, manganese, iron, and sulfur. High levels of copper, zinc, and cobalt were inhibitory to cellulose digestion. These investigators concluded that rumen microorganisms can tolerate a wide range of concentrations of certain mineral elements.

Trace minerals in the diet of steers were studied by Bentley et al. (1954). A trace mineral supplement significantly increased the average daily gain of steers individually fed a ration of mature timothy hay, ground ear corn, urea, cerelose, calcium, phosphorus, iodized salt, and vitamin A. Studies indicated that cobalt increased gains and the vitamin B_{12} content of the liver. The addition of trace minerals also increased feed intake and feed efficiency.

Barley

Barley is one of the world's most widely used grains and can be grown in a greater variety of climates than corn, wheat, or oats (Nutrition Reviews, 1958). It is best adapted to cool summers and regions of well-drained soils (Morrison, 1959).

Barley is believed to have originated in Western Asia where it served as food for man and beast. The earliest settlers brought barley to the North American continent (Encyclopedia Americana, 1961).

Barley ranks fourth in importance as a grain crop in the United States (Morrison, 1959). About two-thirds of the 340 million bushels of

barley used in the United States in 1958 was fed to livestock (Senti and Maclay, 1961). Barley averages 12.7 percent protein, except in the Pacific Coast states where the protein content is lower (Morrison, 1959). Proteins found in barley are albumins, globulins, prolamine, and glutelin (Barton-Wright, 1958). The protein of barley is not of good quality, though it is of better quality than the protein of corn. The hulls form 15 percent of the barley. Barley has about 5.4 percent fiber. It lacks carotene and vitamin D and is low in riboflavin. It is rich in niacin, with three times as much as is present in corn (Morrison, 1959).

The amino acid nitrogen of barley in percent of total nitrogen follows (Ljungdahl and Sandegren, 1956):

amino acid	% of total nitrogen
Alanine	3.4
Arginine	9.9
Aspartic acid	3.4
Cystine	0.6
Glutamic acid	13.6
Glycine	7.1
Histidine	3.5
Isoleucine	2.1
Leucine	4.7
Lysine	4.9
Phenylalanine	2.0
Proline	6.3
Serine	3.0
Threonine	3.3
Tyrosine	1.3
Valine	3.1

When barley is steam-rolled, the moisture content is increased 3 to 5 percent (Taylor et al., 1960). Steam-rolling as compared to dry-rolling resulted in a 6.5 percent increase in rate of gain of steers and a 5 percent saving in feed required per unit of gain. Steers that averaged 596

pounds initially gained 3.10 pounds per day for 126 days on the steam-rolled barley ration. The steers required 742 pounds of feed per 100 pounds of gain.

Urban et al. (1959) conducted work with Hereford and Angus calves to compare two methods of preparing barley. Calves fed steam-rolled barley consumed 12 percent more grain and gained 15 percent faster than calves that received finely ground or pelleted barley. The feed efficiency and feed cost per 100 pounds of gain were also better for the calves fed the steam-rolled barley. The calves showed a preference for steam-rolled barley when they were fed in self-feeders.

Barley was compared with milo by Taylor et al. (1961) as feed for yearling beef steers during a summer and a winter study. Both dry-rolled and steam-rolled barley were used. There was no significant difference in the rate of gain between the steers fed milo and those fed barley. The steers fed barley required less feed per 100 pounds of gain than the steers fed milo during the summer. In a wintering experiment, the barley-fed steers gained 8 percent more per day on 13.8 percent less feed per 100 pounds of gain than the steers fed milo. A slight advantage in feed efficiency was also shown for steam-rolled over dry-rolled barley.

Physical Balance of the Ration

Some cattle feeders prefer cattle fattening rations which are relatively high in roughage, whereas other feeders favor high concentrate fattening rations. Factors such as prices, availability of feeds, storage

costs, handling and processing, and personal preference determine the physical form of the ration fed.

Concentrate-roughage ratios. Dowe et al. (1955) fed fattening steers rations that ranged from 1:1 to 5:1 concentrate-roughage ratios. The concentrate used was corn or corn and soybean oil meal and the roughage was alfalfa hay. The smallest daily gain was obtained on the 1:1 ratio, and the steers fed the 2:1 ratio of concentrate to roughage had the largest daily gain. There was a decrease in total feed consumption based on a percentage of the live weight as the proportion of concentrates was increased. Feed efficiency was best for the 5:1 and 4:1 concentrate-roughage levels and poorest for the 1:1 ratio. The dressing percentage was highest for the steers fed the 5:1 ration (60.7%) and lowest for the steers fed the 1:1 concentrate-roughage ration (59.3%).

Keith et al. (1954) found that Hereford steer calves fed a ration containing two parts concentrate to one part alfalfa hay made 17 percent more gain and required 15 percent less feed per 100 pounds of gain than calves fed a 1:1 ratio of concentrate to alfalfa hay. In a later study by Keith et al. (1961), these workers fed steers concentrate-roughage mixtures that ranged from 1:3 to 4:1 to study the economy of different ratios. Results showed that the rate and economy of gain were not increased after the ration mixture reached 66 percent concentrate. The 1:1 ratio was the most economical mixture for fattening beef steers.

Experiments were conducted by Richardson et al. (1953) with Hereford steer calves fed varying ratios of alfalfa hay and coarsely ground milo grain for 203 days. Calves fed a ration with a concentrate-roughage ratio

of 3:1 had higher average daily gains (2.20 lb.) than calves fed diets that contained concentrate-roughage ratios of 1:1 (2.13 lb.) and 5:1 (2.10 lb.). The cattle fed the 5:1 concentrate-roughage mixture consumed about the same amount of grain as the cattle fed the 3:1 mixture. Daily gain declined toward the end of the feeding period for steers fed the 3:1 and 5:1 mixtures.

Pahnish et al. (1956) conducted experiments with Hereford steers to study the effect of roughage levels in a fattening ration. The roughages used were chopped alfalfa, cereal hay, cereal straw, and cottonseed hulls. The concentrate consisted of equal amounts of barley and hegari grain. Test rations with concentrate to roughage ratios of 2:1, 1:1, 1:2, and 1:3 were compared in a 105-day feeding period. The pounds of total digestible nutrients (TDN) and the therms of energy required per pound of gain are shown in Table I. The least TDN per pound of gain were required

TABLE I. REQUIREMENTS PER POUND OF GAIN.

Concentrate-roughage ratio	Pounds of TDN	Therms
2:1	6.15	13.168
1:1	6.36	13.258
1:2	6.11	13.187
1:3	5.92	12.503

by the steers fed the concentrate-roughage mixture of 1:3, and the most TDN were required by the animals fed the 1:1 ration. The average daily gain decreased slightly as the roughage content of the ration increased. The steers fed the 2:1 concentrate-roughage ration consumed about 2.0 to 2.5 pounds less feed per day than did the other steers. The feed efficiency increased as the proportion of concentrate in the ration increased.

Investigations on the feeding of all-concentrate rations to beef cattle were conducted by Wise et al. (1961). The calves were fed a basal ration of ground shelled corn, urea, cottonseed oil, minerals, and vitamins, containing 1.5 percent fiber. Five percent sodium and potassium acetate was added to the basal ration as a buffering agent in the rumen of one group of calves. These calves were compared with calves fed the basal diet with the daily addition of 2.5 pounds of coastal Bermuda-grass hay. The presence of hay did not cause any significant increase in the consumption of the basal diet. Average daily gains were similar for steers fed the two rations. Feed efficiency was best for steers fed the basal diet. Sodium and potassium acetate fed at 5 percent of the ration was thought to be excessive for cattle fed an all-concentrate ration. It was concluded that calves were able to perform satisfactorily on all-concentrate rations if the ration provided adequate amounts of the essential nutrients and the buffering capacity of the rumen was adequate.

Pope et al. (1956) fed fattening Hereford steers and heifers three rations with concentrate-roughage mixtures of 1:1, 2:1, and 4:1. Results indicated there was no consistent difference in performance of steers as affected by the concentrate-roughage ratio. The steers fed the higher roughage level consumed the most feed and had the poorest feed conversion. The feed consumption decreased as the percent of concentrates in the ration increased. The concentrate intake was about the same for all rations.

Digestibility. Work conducted by Richardson et al. (1956) with beef

steers and heifer calves showed that the greatest digestibility of all nutrients was obtained when a mixture of three parts concentrate to one part roughage was fed, followed by a ration with a 5:1 concentrate-roughage ratio. A 1:1 ratio resulted in the lowest nutrient digestibility. An increase or decrease in the 3:1 concentrate-roughage ratio resulted in a decrease in digestibility of the nutrients. The cattle fed the most roughage required the most feed per 100 pounds of gain.

A digestibility study, in which several dairy heifers were maintained on an all-concentrate diet from birth to over 18 months of age, was conducted by Mead et al. (1935). A like group of heifers was fed the same concentrate mixture with the addition of 14 percent roughage. The heifers fed all concentrates for 18 months were normal in size but showed frequent bloating and irregular rumination. The crude fiber in the all-concentrate ration was 32 percent less digestible than in the ration with 14 percent roughage. The digestibility of all other nutrients was about the same for the two rations. When the concentrate ration was finely ground, the digestibility of the crude fiber was significantly lowered.

In an experiment conducted by Haynes et al. (1955), the digestibility of feed that contained (1) 100 percent hay, (2) 75 percent hay and 25 percent grain, (3) 50 percent hay and 50 percent grain, and (4) 35 percent hay and 65 percent grain was approximately the same.

Watson et al. (1950) reported that the digestibility of barley fed beef steers was the same when fed alone or with timothy or alfalfa hay.

Dowe et al. (1955) conducted 28 digestion trials using five ratios

of corn to alfalfa hay. The concentrate-roughage ratios were 1:1, 2:1, 3:1, 4:1, and 5:1. The apparent digestibility of the dry matter and ether extract increased as the corn was increased in the ration. The coefficient of apparent digestibility for nitrogen-free extract, crude fiber, and protein was similar for all rations.

Carcass Data

Such criteria as dressing percentage, carcass shrinkage, and carcass grade can often determine a profit or a loss to the cattle feeder.

Factors affecting dressing percentage are (1) condition, (2) "fill" at time final weight is taken, and (3) type and quality of the animal. In an experiment in which steers were fed varying concentrate-roughage rations, the steers fed a 5:1 mixture of concentrate to roughage had the highest dressing percentage (60.7%). Steers fed a 1:1 mixture had the lowest dressing percentage (59.3%). Steers fed a 2:1 and 3:1 mixture of concentrate to roughage were intermediate between the other two groups. The steers receiving the 1:1 concentrate-roughage mixture also had the lowest carcass grades (Cyaert and Bouckaert, 1961).

Richardson et al. (1956) found some differences in carcass grade in investigations with different concentrate-roughage ratios fed beef calves. Animals fed a 1:1 ratio of concentrate to roughage failed to attain as much finish or as high carcass grades as animals fed a 3:1 or 5:1 concentrate-roughage mixture.

Rumenitis. High concentrate rations have increased the incidence of rumenitis (inflammation of the rumen) and ruminal parakeratosis (RPK), a chronic form of rumenitis. Ruminal parakeratosis is a noncontagious

disease characterized by hardening, enlargement, and clumping of mucosal papillae in the rumen. Microscopically, the disease is expressed as an accummulation of excessive layers of keratinized, nucleated, squamous epithelial cells on the papillae (Nutrition Reviews, 1958). Most of these disturbances of the rumen associated with pelleted and high concentrate rations are of a chronic nature. They often cause decreased performance without gross symptoms of a disease.

Jensen et al. (1954) studied rumenitis and its relation to rate of change of a ration from roughage to concentrate and the proportion of concentrates in the ration. At the beginning of the experiment, all cattle were fed alfalfa hay only. The change to the fattening ration was made gradually over a 12 to 30 day period. In all groups, some animals had rumen inflammation, but the extent of rumenitis was significantly greater in the groups of cattle which changed to the fattening ration in 12 days. These investigators conducted a second experiment with Hereford steers in which different concentrate-roughage ratios were studied. Cattle receiving a 3:1 concentrate-roughage ration had significantly more rumenitis than those fed a 2:1 and a 1:2 concentrate-roughage diet.

Beardsley et al. (1959) conducted steer fattening experiments to study rumen effects with different concentrate-roughage ratios in pelleted and unpelleted mixtures. Feed mixtures with concentrate to roughage ratios of 70:30, 55:45, and 40:60 were fed either finely ground, pelleted, or coarsely ground and unpelleted for 141 days. Slaughter examination of the steers revealed marked tissue changes, including

parakeratosis, in steers on the high concentrate pelleted ration but not in steers on a high roughage unpelleted ration.

In a study by Ward et al. (1962) of 15 cattle fattened on all-concentrate rations, four had normal rumens, six had medium to severe cases of RPK, and five had slight cases. Nine of the 15 steers fed an all-concentrate ration had dark colored rumens but there was no apparent relation between weight gain and color of the rumen or between color and RPK. In an experiment with 18 heifers fattened on an all-concentrate ration for 120 days, five showed evidence of active parakeratosis while 11 animals showed loss of papillae from the floor of the ventral sac of the rumen.

In work by Vidacs et al. (1960), rumen epithelium changes much like parakeratosis were observed within four to six days after changing from hay to a dried beet pulp ration. When the ration was changed to hay again, the epithelium returned to normal, but recovery was slower than the development of parakeratosis.

Jensen et al. (1954) conducted an experiment in which animals previously fed alfalfa were fed a full feed of barley. A loss of ruminal motility occurred after the second feeding of barley. The rumens showed generalized inflammation and necrosis. The papillae were dark, enlarged, necrotic, and friable, especially in the ventral sac of the rumen.

There is also evidence that minerals are deposited on the rumen papillae when fed a high concentrate diet. Brownlee et al. (1961) found that the rumens of calves fed a calf concentrate all gave a positive test

for iron, whereas the rumens of calves fed hay gave a negative test for iron.

Certified Steers

Certified steers are beef steers sired by Individual Performance Record bulls. The sire must have been owned by a member of the Montana Beef Cattle Performance Association. The bull has a certified record of daily gain on a feeding test. Performance testing of beef cattle has been conducted for about 20 years in Montana (Orcutt, 1957).

A sire testing and individual evaluation program has been in progress since 1942 in Texas. In 140-day tests with 1,053 Hereford bulls, wide differences in gaining ability were found, ranging from 1.15 to 2.82 pounds per head daily. There was a heritability of approximately 53 percent for rate of gain in the feedlot (Patterson et al., 1955).

In a study at the United States Range Livestock Experiment Station in Miles City, Montana, eight steer calves from each sire were selected at random from each sire's calf crop and were fed on record-of-performance trials. The experiments were conducted between 1938 and 1942 with a total of 117 steers sired by 23 bulls. The length of the feeding periods varied between years. The steers were all full fed a grain mixture of six parts corn, three parts beet pulp, one part wheat bran, one part linseed meal, and one-half part alfalfa leaf meal. The roughage was good grade alfalfa hay. Two methods were used to estimate heritability. These were (1) half-sib correlations obtained by analysis of variance and (2) regressions of progeny average on sires obtained from covariance analysis. Heritabilities obtained from intra-sire correlations were final

feedlot weight 81 percent, gain in the feedlot 99 percent, and efficiency of gain 75 percent. Heritabilities obtained from sire progeny regression were final weight in feedlot 69 percent, daily gain 46 percent, and efficiency of gain 54 percent (Knapp, Jr. and Nordskog, 1946).

Heritability of the previous animals was also estimated by the use of the paternal half-sib correlation from analysis of variance by Knapp, Jr. and Nordskog (1946). Heritabilities obtained were slaughter grade 63 percent, carcass grade 84 percent, dressing percentage 1 percent, and area of loin eye muscle 69 percent. It was concluded that there is less heritability of traits concerned with quality of the product than in traits related to growth.

PURPOSE

The experiments reported herein were initiated to evaluate different physical preparations of barley and various levels of hay in fattening cattle rations.

Specific objectives of the experiments were (1) to compare the feeding value of steam-rolled barley, steam-rolled barley plus five percent molasses, and dry-rolled barley; (2) to compare the performance of steers fed two, five, six, and no pounds of hay plus a full feed of barley; and (3) to compare the gains of certified steers sired by performance tested bulls and steers sired by untested bulls.

PROCEDURE

Two similar experiments (trial I and trial II) were conducted to compare the value of steam-rolled and dry-rolled barley fed with varying levels of hay to fattening beef steers.

Trial I

Pretrial procedures. Forty yearling Hereford steers were purchased from the Climbing Arrow Ranch at Three Forks, Montana, April 7, 1960. They were grazed during the summer of 1960 on irrigated pasture. The cattle were moved to the newly completed Montana State College feedlot September 31, 1960. The feedlot is located one mile west of the college campus.

The pretrial treatment consisted of a full feed of mixed hay plus one pound of steam-rolled barley per head daily.

On October 3, 1960, the steers were ear-tagged for identification, branded, and assigned to four treatments of ten head each by random stratification according to weight.

Treatments and experimental procedures. The experimental animals were weighed on experiment October 15 after a 16-hour shrink without food or water. Individual weights were taken every 28 days during the 140-day experiment.

The design of the experiment is shown in Table II. Steers in lots 1, 2, and 3 were fed steam-rolled barley and lot 4 steers received dry-rolled barley. They were initially fed five pounds of barley and 16 pounds of hay per head daily. The barley was increased approximately two pounds per head per week, until the steers received a full feed of barley. The hay was gradually decreased until, after four weeks of the trial, the

steers received the following levels of hay per steer daily: lot 1, six pounds; lot 2, two pounds; lot 3, no hay; and lot 4, two pounds. The cattle were fed twice daily after the first three weeks of the experiment.

TABLE II. DESIGN OF TRIAL I (OCTOBER 15, 1960, TO MARCH 4, 1961; 140 DAYS).

Lot and ration number	1	2	3	4
Steers/lot	10	10	10	10
Treatment/steer daily				
Barley, rolled	steam	steam	steam	dry
Hay, lb. 1/	6	2	0	2
Supplement, lb. 2/	2	2	2	2

1/Pounds of mixed grass-alfalfa hay fed after the first five weeks.
2/A 20% protein supplement with 10,000 I. U. of vitamin A per pound and trace minerals added.

All steers received two pounds per day of a 20 percent protein supplement. The composition of the supplement in shown in Table III.

TABLE III. THE COMPOSITION OF THE PROTEIN SUPPLEMENT FED STEERS IN TRIAL I AND TRIAL II.

Ingredient	Percent of supplement
Wheat mill run	40
Alfalfa meal, dehydrated	25
Soybean oil meal	10
Cottonseed meal	10
Linseed oil meal	5
Dicalcium phosphate	1
Limestone	4
Premix 1/	5

1/Contained 95% wheat mill run, 4% trace minerals, and 1% vitamin A. It contained 10,000 I. U. of vitamin A per pound. The cattle received a mineral supplement free choice, which consisted of one-third salt, one-third bone meal, and one-third defluorinated rock phosphate. The chemical

composition of the barley, hay, and protein supplement fed the steers is shown in Table IV.

TABLE IV. CHEMICAL ANALYSIS OF BARLEY, HAY, AND SUPPLEMENT FED STEERS IN TRIAL I. 1/

Ingredients	Grass-alfalfa hay	Steam-rolled barley	Dry-rolled barley	Protein supplement
Moisture	7.3	10.0	10.1	7.5
Protein	8.2	11.0	11.5	23.8
Ether extract	2.2	2.5	2.2	3.7
Crude fiber	29.8	5.1	5.2	12.3
Calcium	0.74	0.07	0.11	1.81
Phosphorus	0.15	0.33	0.34	0.80
Ash	6.6	2.7	2.9	5.7
Carotene (mg./lb.)	26.9	1.7	trace	5.6

1/With the exception of carotene, all ingredients are reported in percent.

Final weights were taken March 4, 1961, after a 16-hour shrink. On March 5, the steers were trucked to the New Butte Butchering Company, Butte, Montana, where they were sold on a carcass-grade basis. The cattle were slaughtered March 6 and 7. Individual rumen samples, number of condemned livers, warm and cold carcass weights, and carcass grades were obtained.

Trial II

Pretrial procedures. Thirty-two Hereford steers were used in trial II. Twenty-four steers were purchased at the Bozeman Livestock Auction and from a local rancher. Eight animals were from the Montana State College herd.

The steers were allotted May 29, 1961, to four treatments of eight steers per treatment by random stratification according to weight and

source. They were fed a pretrial ration of mixed grass-alfalfa hay and two pounds of steam-rolled barley per head daily.

Treatments and experimental procedures. Procedures similar to those described for trial I were followed. The experiment began June 6, 1961. The design of the experiment is shown in Table V. Individual weights were obtained about every 28 days. There were 38 days in the first weigh period due to improper functioning of the scale.

TABLE V. DESIGN OF TRIAL II (JUNE 6, 1961, TO NOVEMBER 6, 1961; 153 DAYS).

Lot and ration number	5	6	7	8
Steers/lot	8	8	8	8
Treatment/steer daily				
Barley, rolled	steam	dry	steam	steam
Hay, lb. 1/	6	2	2	0
Supplement, lb. 2/	2	2	2	2

1/Pounds of grass-alfalfa hay fed after the first three weeks. After 10 weeks, the hay fed lot 5 steers was decreased to four pounds.
2/A 20% protein supplement with 10,000 I. U. of vitamin A per pound. Trace minerals were also added.

Steers in lots 5, 7, and 8 received steam-rolled barley. Lot 6 steers received dry-rolled barley. All animals were intially fed six pounds of barley daily. The barley was increased about two pounds per steer each week and the mixed grass-alfalfa hay was decreased until the desired level of hay was reached. Lot 5 steers received six pounds of hay per head daily. Lots 6 and 7 steers received two pounds of hay and lot 8 steers no hay. This level of hay was attained after about three weeks of the experiment. The hay fed lot 5 steers was decreased to four pounds per steer after 10 weeks of the trial because of excessive wastage

of the hay. The steers were fed the same protein and mineral supplement as used in trial I. Chemical analysis of the feeds used during trial II are given in Table VI.

TABLE VI. CHEMICAL ANALYSIS OF BARLEY, HAY, AND SUPPLEMENT FED STEERS IN TRIAL II. 1/

Ingredients	Grass-alfalfa hay	Steam-rolled barley	Dry-rolled barley	Protein Supplement
Moisture	6.6	8.6	9.8	7.5
Protein	8.9	11.7	12.2	23.8
Ether extract	1.7	2.4	1.7	3.7
Crude fiber	29.2	5.0	5.5	12.3
Calcium	1.00	0.25	0.29	1.81
Phosphorus	0.17	0.32	0.30	0.80
Ash	18.1	2.4	2.4	5.7
Carotene (mg./lb.)	5.0	2.3	0.0	5.6

1/With the exception of carotene, all ingredients are reported in percent.

The steers were shrunk 16 hours without food or water and weighed off experiment November 6, 1961, after a 153-day feeding period. They were sold at the New Butte Butchering Company, Butte, Montana, on a carcass-grade basis. Individual data, including rumen samples, number of condemned livers, warm and cold carcass weights, and carcass grades, were obtained.

Wintering Trial

Pretrial procedures. Forty-eight Hereford calves were used in a wintering experiment. Twenty calves were purchased from the Bozeman Livestock Auction, four calves were from the Red Bluff, Montana Agricultural Experiment Station herd, and 24 calves were obtained from a rancher near Deer Lodge, Montana. The latter calves were sired by Individual Performance Record (IPR) bulls and are referred to as certified steers.

The experimental animals were allotted to four treatments of 12 steers each by random stratification according to sire and source on November 19, 1960.

The calves were fed a full feed of mixed grass-alfalfa hay for one month prior to the initiation of the experiment. One week before the beginning of the trial, each animal received two pounds of steam-rolled barley per day.

Treatments and experimental procedures. The 84-day wintering trial was initiated December 30, 1960, following a 16-hour shrink. Individual weights were obtained at the beginning of the experiment and every 28 days thereafter.

The design of the experiment is shown in Table VII. The calves

TABLE VII. DESIGN OF THE WINTERING TRIAL (DECEMBER 30, 1960, TO MARCH 24, 1961; 84 DAYS).

Lot and ration number	1	2	3	4
Steers/lot	12	12	12	12
Daily ration/steer				
Barley, rolled	steam	steam + 5% molasses	steam + 5% molasses + celluade	dry
Hay, grass-alfalfa 1/	X	X	X	X
Supplement, lb. 2/	2	2	2	2

1/All calves received a full feed of hay.
2/Five percent celluade was added to the protein supplement for lot 3 calves.

were started on two pounds of barley and nine pounds of hay. Lot 1 steers received steam-rolled barley. Steers in lots 2 and 3 received steam-rolled barley with five percent molasses added, and lot 4 steers

received dry-rolled barley. The steers were fed a limited feed of barley and a full feed of hay. At the end of the wintering period, each animal received about six pounds of barley per day. Each steer received two pounds of a 20 percent protein supplement daily during the experiment. The supplement contained 10,000 I. U. of vitamin A per pound. Five percent celluade replaced linseed oil meal in the supplement fed the steers in lot 3. Celluade, a product containing 24 percent protein, vitamins, minerals, and organic salts was designed to increase the digestion of cellulose. The composition of celluade is shown in Appendix Table I.

Table VIII shows the composition of the protein supplements. A

TABLE VIII. COMPOSITION OF PROTEIN SUPPLEMENTS IN THE WINTERING TRIAL.

Lot number	1, 2, 4	3
	% of supplement	% of supplement
Ingredients:		
Wheat mill run	39.0	39.0
Alfalfa meal, dehydrated	25.0	25.0
Soybean oil meal	10.0	10.0
Cottonseed meal	10.0	10.0
Linseed oil meal	5.0	0.0
Defluorinated phosphate	1.0	1.0
Celluade	0.0	5.0
Beet pulp, high molasses	5.0	5.0
Premix 1/	5.0	5.0

1/ Contained 92% wheat mill run, 6% trace minerals, and 2% vitamin A. This provided 10,000 I. U. of vitamin A per pound of supplement.

mineral mixture and salt were fed free choice during the trial. The mineral mixture contained one-third bone meal, one-third defluorinated rock phosphate, and one-third salt. All steers were fed equal amounts of hay, barley, and protein supplement throughout the experiment.

The wintering experiment was terminated March 24, 1961. Individual final weights were obtained after a 16-hour shrink.

Fattening Trial

The steers used in the wintering trial were continued on a 179-day fattening experiment with the same rations fed. The final weights obtained on the wintering trial were used as the initial weights for the fattening trial.

Treatments and experimental procedures. The level of hay was gradually reduced during the first six weeks of the trial. Two pounds of hay per animal daily were fed after the sixth week. The barley was progressively increased until the steers received a full feed of barley after about five weeks of the trial. Each animal received one pound per day of a 20 percent protein supplement. The composition of the supplements is shown in Table IX. Ten percent celluade replaced 7 percent

TABLE IX. COMPOSITION OF PROTEIN SUPPLEMENTS FED STEERS DURING THE FATTENING EXPERIMENT.

Lot number	1, 2, 4	3
	% of supplement	% of supplement
Ingredients:		
Wheat mill run	40.0	33.0
Alfalfa meal, dehydrated	25.0	25.0
Soybean oil meal	8.0	7.5
Cottonseed meal	10.0	7.5
Linseed oil meal	5.0	5.0
Limestone	6.0	6.0
Defluorinated phosphate	1.0	1.0
Celluade	0.0	10.0
Premix 1/	5.0	5.0

1/ Contained trace minerals and 20,000 I. U. of vitamin A per pound of supplement.

wheat mill run, 2.5 percent cottonseed meal, and 0.5 percent soybean oil meal in the protein supplement fed the lot 3 steers. Steers in lots 1,

2, and 4 were not fed celluade. The supplements contained 20,000 I. U. of vitamin A per pound. A chemical analysis of the experimental feeds is given in Table X.

One steer in lot 2 bloated several times and was removed 67 days after the trial began. One lot 4 steer died of a ruptured rumen 6 days before the completion of the trial.

The steers were weighed off experiment September 19, 1961, after a 16-hour shrink. They were slaughtered at the New Butte Butchering Company, Butte, Montana, and sold on a carcass-grade basis. Individual rumen samples, number of condemned livers, warm and cold carcass weights, and carcass grades were obtained.

TABLE X. CHEMICAL ANALYSIS OF FEEDS FED STEERS ON FATTENING TRIAL. 1/

Ingredients	Supplement fed lot 3 steers	Supplement fed lots 1, 2, and 4 steers	Grass-alfalfa hay	Steam-rolled barley	Dry-rolled barley	Steam-rolled barley plus molasses
Moisture	6.7	7.2	6.6	8.6	9.8	8.9
Protein	23.1	23.4	8.9	11.7	12.2	12.2
Ether extract	3.5	3.5	1.7	2.4	1.7	2.2
Crude fiber	13.4	13.3	29.2	5.0	5.5	5.3
Phosphorus	0.91	0.89	0.17	0.32	0.30	0.36
Calcium	3.0	3.3	1.0	0.25	0.29	0.50
Ash	11.1	11.1	18.1	2.4	2.4	3.2
Carotene (mg./lb.)	2.3	2.7	5.0	2.3	0.0	trace

1/With the exception of carotene, all ingredients are reported in percent.

RESULTS AND DISCUSSION

Trial I

The forty yearling Hereford steers averaged about 844 pounds initially and 1,175 pounds at the end of the 140-day feeding period. There was a difference of 18 pounds in average initial weight between the lightest and the heaviest group of steers. The animals used in this trial were large and varied in weight. There was about 200 pounds difference in initial weight between the lightest and the heaviest animal in any one of the lots (Appendix Table II).

Weight gains. A summary of weight gains is given in Table XI. The steers in lots 2 and 4, fed two pounds of hay per animal daily plus steam-rolled and dry-rolled barley respectively, had the best average daily gain of 2.50 pounds. The animals that received ration 1, which consisted of steam-rolled barley and six pounds of hay per steer daily, had the poorest average daily gain of 2.15 pounds. Lot 3 steers, fed steam-rolled barley without hay after the first five weeks of the trial, had an average daily gain of 2.37 pounds. An analysis of variance showed there was a statistically significant difference ($P<0.05$) in average daily gain between lot 2 and lot 1 steers and between lot 4 and lot 1 steers.

Figure 1 shows the average daily gain by weigh periods for the four groups of cattle. The average daily gain increased the first 56 days and then steadily decreased in all groups of steers. The decrease in average daily gain the last three weigh periods was irregular. The lot 2 steers, fed steam-rolled barley plus two pounds of hay, gained more weight than

TABLE XI. SUMMARY OF WEIGHT GAINS, FEED CONSUMPTION, FEED CONVERSION, AND FINANCIAL RETURN FOR TRIAL I STEERS.

Lot and ration number	1	2	3	4
Daily treatment/steer				
Barley, rolled	steam	steam	steam	dry
Hay, lb.	6	2	0	2
Avg. wts. (lb.)				
Initial	848	845	832	850
Final	1149	1194	1164	1201
Gain	301	349	332	351
Daily gain	2.15	2.50	2.37	2.50
Avg. daily ration (lb.)				
Barley	16.09	17.78	18.25	18.36
Supplement	1.98	1.98	1.98	1.98
Hay	6.60	3.25	0.47	3.04
Salt and mineral	0.06	0.06	0.06	0.06
Total	24.73	23.07	20.76	23.44
Concentrate-roughage ratio	2.7:1	6.2:1	40.7:1	6.8:1
Feed/cwt. of gain (lb.)				
Barley	748.38	711.18	770.04	734.41
Supplement	92.14	79.23	83.62	79.20
Hay	306.80	130.33	19.73	121.40
Salt and mineral	2.95	2.57	2.71	2.57
Total	1150.27	923.31	876.10	937.58
Cost of feed/cwt. of gain ($) 1/	21.80	18.73	18.87	19.02
Financial return/steer ($)				
Initial cost 2/	190.69	190.12	187.09	191.36
Feed cost	65.62	65.37	62.65	66.76
Trucking charge	2.74	2.74	2.74	2.74
Total investment 3/	259.05	258.23	252.48	260.86
Gross return 4/	261.76	262.67	262.98	272.80
Net return	2.71	4.44	10.50	11.94
Carcass grade				
Choice	8	8	7	7
Good	2	2	3	3

1/Feed prices: steam-rolled and dry-rolled barley, $42/ton; protein supplement, $53.40/ton; and mixed alfalfa-grass hay, $23/ton.
2/$22.50/cwt.; this is an estimated cost on October 15, 1960, as the cattle were purchased April, 1960.
3/Labor costs excluded.
4/Sold on a carcass-grade basis: $38/cwt. for choice and $37/cwt. for good.

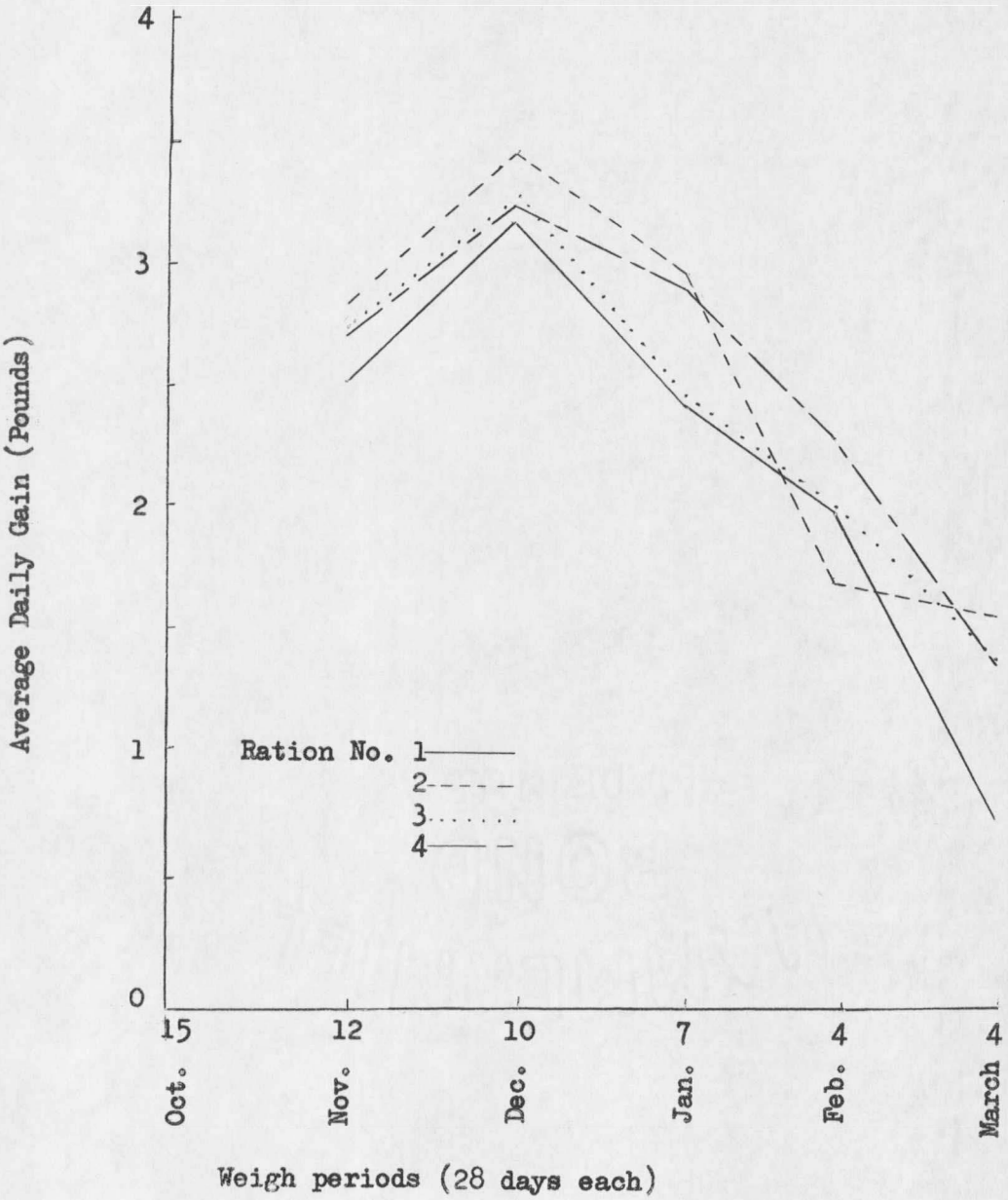

Figure 1. Average Daily Gain Per Weigh Period for Steers in Trial I.

the other steers during one period and gained less than the other steers the following weigh period. All four groups of steers had fairly constant relative average daily gains during the second weigh period.

Figure 2 shows the cumulative average daily gain by weigh periods. The cumulative average daily gain increased during the first two weigh periods and than gradually decreased. The decrease was less rapid for cattle in lots 2 and 4, fed steam-rolled and dry-rolled barley plus two pounds of hay, than for the cattle in the other lots. During the final weigh period, the cumulative average daily gain for the cattle in all lots dropped slightly below the gain made the first weigh period. Lot 1 cattle, fed steam-rolled barley plus six pounds of hay per head daily, were consistently below the other cattle in cumulative average daily gain throughout the trial.

Feed consumption. The animals that received ration 1 had the highest average daily feed consumption of 24.73 pounds (see Table XI). The steers that received ration 3 consumed only 20.76 pounds of feed per animal daily, whereas lots 2 and 4 steers consumed 23.07 and 23.44 pounds of feed per head daily. There was a decrease in total feed consumption as the proportion of concentrate to roughage increased. A similar observation was reported by Pope et al. (1956).

The steers fed two pounds of hay per head daily (lots 2 and 4) consumed about the same amount of barley as the steers fed an all-concentrate ration. The steers fed six pounds of hay per animal daily (lot 1) consumed only about two pounds less barley per head daily than the other

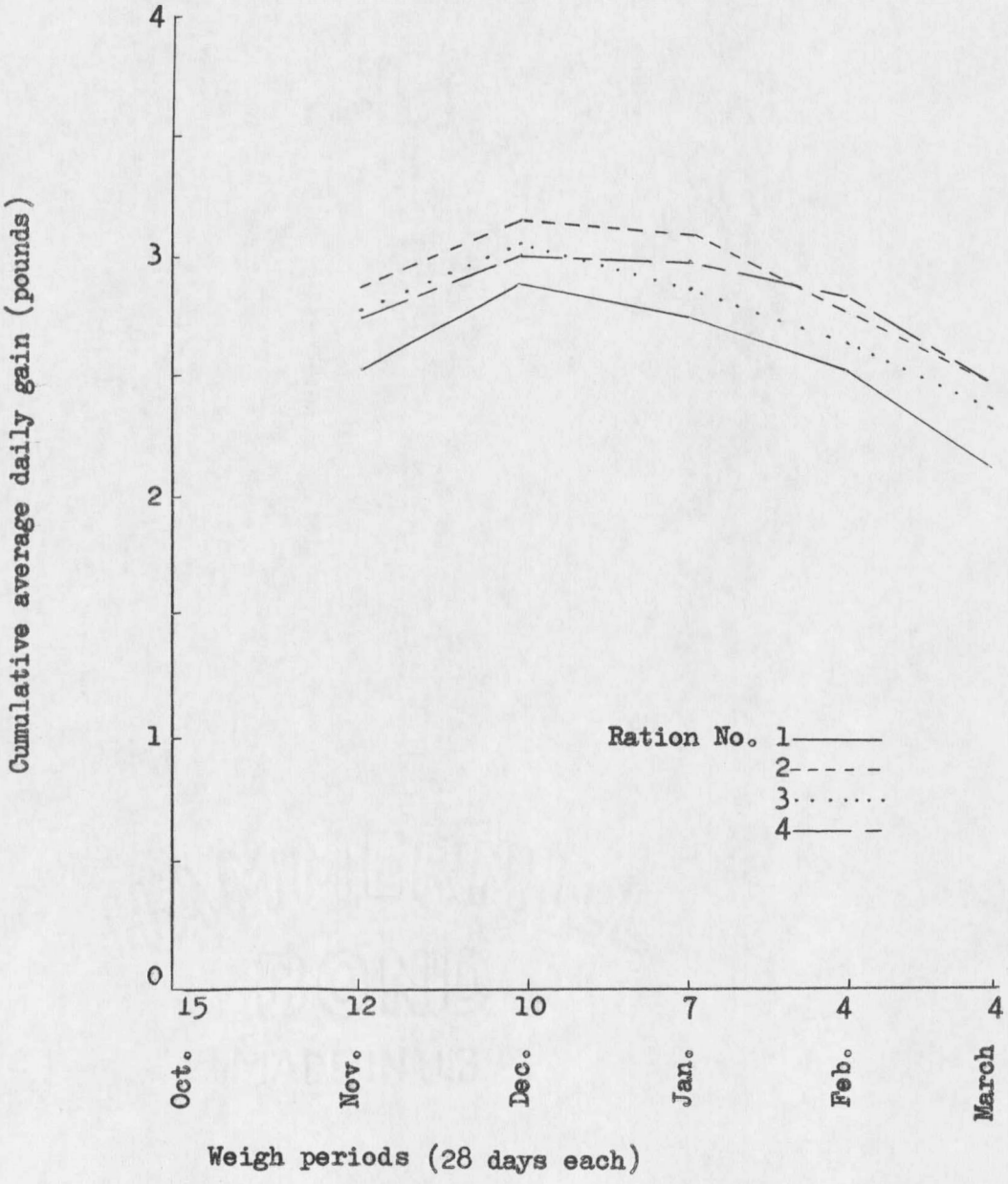

Figure 2. Cumulative Average Daily Gain Per Weigh Period for Steers in Trial I.

experimental animals. The steers fed dry-rolled barley (lot 4) consumed about one-half pound more barley per animal daily than the steers that received steam-rolled barley (lot 2).

In all lots, the steers reached a peak in feed consumption the first 84 days of the trial and then declined. It was noticed that the decline in feed consumption occurred one weigh period after the decline in average daily gain. Therefore, it appears that the decline in weight gain was not a direct result of a decrease in feed consumption. It seems that the addition of roughage to the diet stimulated the appetite of the animals.

Feed efficiency. The feed required per 100 pounds of gain, as shown in Table XI, was lowest for the steers that received an all-concentrate ration (lot 3) and highest for the animals fed six pounds of hay (lot 1). Lot 2 animals, fed steam-rolled barley plus two pounds of hay, were slightly more efficient than lot 4 steers, fed dry-rolled barley plus two pounds of hay. Similar results were reported by Taylor et al. (1960). They found that cattle fed steam-rolled barley required five percent less feed per 100 pounds of gain than cattle fed dry-rolled barley. The cattle in all lots were most efficient the first 56 days of the experiment. There was a progressive increase in the feed required per 100 pounds of gain by all steers after the first 56 days of the trial.

Feed costs. There was little difference in feed cost per 100 pounds of gain among steers in lots 2, 3, and 4, as shown in Table XI. The feed

cost per hundredweight of gain was about three dollars higher for lot 1 steers than for any other group of steers. The steers in all lots gave a positive financial return. Lot 4 steers gave the highest average return and lot 1 steers gave the least return.

Carcass data. There was little difference in the carcass grade of the steers (see Table XI). The steers fed rations 1 and 2 graded 80 percent choice and 20 percent good. The animals that received rations 3 and 4 graded 70 percent choice and 30 percent good.

Rumen samples of cattle that received six pounds and two pounds of hay per head daily (lots 1, 2, and 4) were normal and showed little variation in physical characteristics. The rumens of steers fed an all-concentrate ration (lot 3) were noticeably darker in color than the rumens of the cattle fed hay. There were also some cases of clumped and crusted papilaae and small areas of depapillation in the rumens of the cattle fed ration 3. There did not seem to be any correlation between rumen parakeratosis and daily gain or between parakeratosis and carcass grade. Ward et al. (1962) reported similar observations. It is not believed that any of the animals showed severe cases of rumen parakeratosis.

Both lot 2 and lot 3 steers had three condemned livers. Most of these livers were abscessed. There were no condemned livers in lots 1 and 4 steers.

Table XII indicates that the average carcass weight of lot 4 steers was about 30 pounds greater than the average carcass weight of steers in lots 1, 2, and 3. This difference is reflected both in the final weight

TABLE XII. AVERAGE CARCASS DATA FOR STEERS FED STEAM-ROLLED AND DRY-ROLLED BARLEY WITH THREE LEVELS OF HAY (TRIAL I).

Lot and ration number	1	2	3	4
Avg. final wt. (lb.) 1/	1149	1194	1164	1201
Avg. warm carcass wt. (lb.)	713.5	716.5	718.6	745.8
Avg. cold carcass wt. (lb.) 2/	692.2	694.9	697.1	723.4
Dressing percentage (final wt. to warm carcass wt.)	62.1	60.0	61.8	62.1
Final wt. to cold carcass wt.	60.2	58.2	59.9	60.2

1/The steers were shrunk 16 hours before taking the final weight.
2/3% shrink from warm weight.

and the dressing percentage. Lots 1 and 4 steers had the highest dressing percentage. The lot 2 steers, which had about the same average final weight as the lot 4 steers, had the lowest dressing percentage. The cold carcass weights were determined by giving the warm weights a calculated shrink of three percent.

Summary. Barley fed either steam-rolled or dry-rolled with two pounds of hay appeared to give about equal results. The steers fed steam-rolled and dry-rolled barley plus two pounds of hay per head daily had the same daily gain. The feed efficiency was slightly better for the steers fed steam-rolled barley. The net return was highest for the steers fed dry-rolled barley, due primarily to a higher dressing percentage. The animals fed steam-rolled barley graded slightly better than those that received dry-rolled barley. Dry-rolled barley was less desirable to handle because of the excessive amount of dust. It was also found that, if the dry-rolled barley became wet, it was less palatable than the

steam-rolled barley. The relative prices as well as personal preference would probably determine the best barley preparation for fattening cattle.

The cattle fed six pounds of hay did not perform as well as steers fed less roughage. However, if the price difference between barley and hay is large, it may be feasible to feed a high level of hay to fattening cattle. This may necessitate a slightly longer fattening period to reach the desired grade.

The cattle fed an all-concentrate ration (lot 3) appeared healthy and performed well in the feedlot. Generally, these cattle had results equal to those of steers fed two pounds of hay (lots 2 and 4), but performed better than the animals that received six pounds of hay per head daily (lot 1).

This experiment indicated that steers fed steam-rolled or dry-rolled barley with two pounds of hay or no hay plus a protein supplement will perform better than steers fed steam-rolled barley with six pounds of hay and a protein supplement.

Trial II

The 32 yearling Hereford steers averaged about 726 pounds initially, as shown in Table XIII. There was 25 pounds difference in average weight of the lightest groups of steers (lot 7) compared with the heaviest lot of steers (lot 6). There was a difference of about 150 pounds in the initial weight of the lightest and heaviest steer in each lot (see Appendix Table VII). The average final weight of the steers was about 1,115 pounds.

TABLE XIII. SUMMARY OF WEIGHT GAINS, FEED CONSUMPTION, FEED CONVERSION, AND FINANCIAL RETURNS FOR STEERS IN TRIAL II.

Lot and ration number	5	6	7	8
Treatment/steer daily				
Barley, rolled	steam	dry	steam	steam
Alfalfa-grass hay (lb.)	5	2	2	0
Avg. wts. (lb.)				
Initial	724	740	715	727
Final	1104	1136	1093	1124
Gain	380	396	378	397
Daily gain	2.48	2.59	2.47	2.59
Avg. daily ration (lb.)				
Barley	15.22	16.43	17.04	18.00
Supplement	2.00	2.00	2.00	2.00
Hay	4.88	2.27	2.28	0.55
Salt and mineral	0.13	0.13	0.13	0.13
Total	22.23	20.83	21.45	20.68
Concentrate-roughage ratio	3.5:1	8.1:1	8.1:1	33.5:1
Feed/cwt. of gain (lb.)				
Barley	614.52	637.79	691.21	695.51
Supplement	80.08	77.04	80.46	76.68
Hay	196.63	88.01	92.23	21.44
Salt and mineral	5.21	4.98	5.18	5.01
Total	896.44	807.82	869.08	798.64
Cost of feed/cwt. of gain ($) 1/	18.11	17.27	18.60	17.78
Financial return/steer ($)				
Initial cost ($23.50/cwt.)	170.14	173.90	168.02	170.84
Feed cost	68.82	68.39	70.31	70.59
Trucking charge ($.25/cwt.)	2.76	2.84	2.73	2.81
Total investment 2/	241.72	245.13	240.06	244.24
Gross return 3/	237.63	251.76	245.39	248.45
Net return	-4.09	6.63	5.33	4.21
Carcass grade				
Choice	4	8	8	8
Good	4	0	0	0

1/Feed prices: steam-rolled or dry-rolled barley, $44/ton; protein supplement, $53.40/ton; and mixed alfalfa-grass hay, $23/ton.
2/Labor costs excluded.
3/$37.50/cwt. for choice and $36.50/cwt. for good.

Weight gains. The steers in lots 6 and 8, fed dry-rolled barley with two pounds of hay per animal daily and steam-rolled barley with no hay respectively, had the best average daily gain of 2.59 pounds (Table XIII). Lot 5 steers, fed steam-rolled barley with about five pounds of hay per animal daily, gained an average of 2.48 pounds per day. Steers in lot 7, fed steam-rolled barley plus two pounds of hay per head daily, gained an average of 2.47 pounds per day. There were no significant differences in average daily gain between any of the groups of steers.

Figure 3 shows the average daily gain of the steers in each lot by weigh periods. The lot 7 steers gradually decreased in average daily gain after the first weigh period. The steers in lots 5, 6, and 8 increased in daily gain the first two weigh periods and then decreased the third weigh period. The average daily gain of the lot 8 steers gradually decreased the third, fourth, and fifth weigh periods. Lots 5 and 6 steers had a slight increase in average daily gain the fourth weigh period, followed by a decrease the final weigh period.

Figure 4 shows that the cumulative average daily gain for steers in lots 5, 6, and 8 reached a peak during the second weigh period and then gradually decreased the remainder of the trial. The cumulative average daily gain of the lot 7 steers decreased steadily from the first weigh period to the end of the trial. Foot rot was partially responsible for poor gains made by several of the lot 7 steers. These poor gains adversely affected the gain of the entire lot of steers. The steers in the other lots were not affected by foot rot.

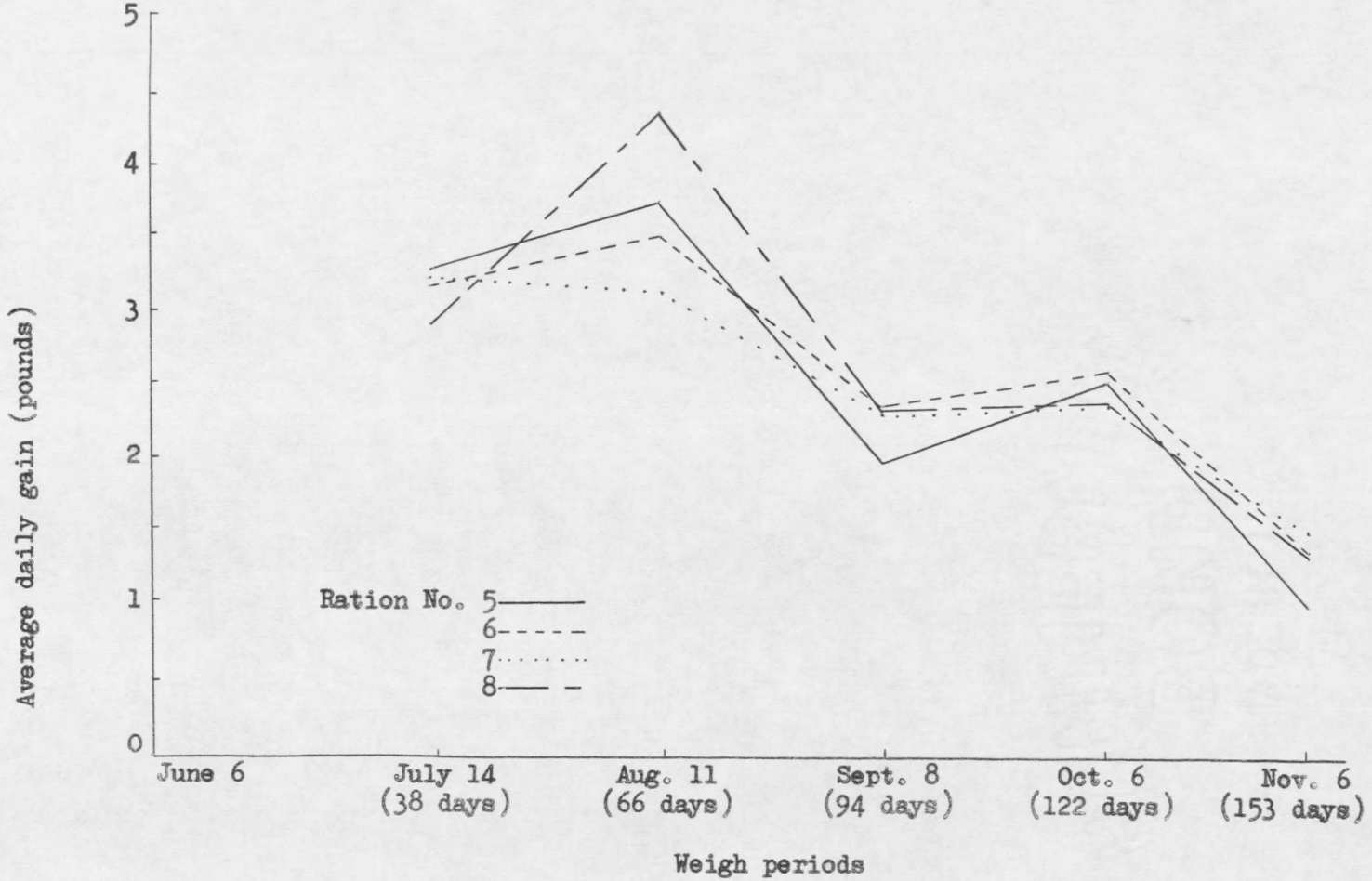

Figure 3. Average Daily Gain by Weigh Period for Steers in Trial II.

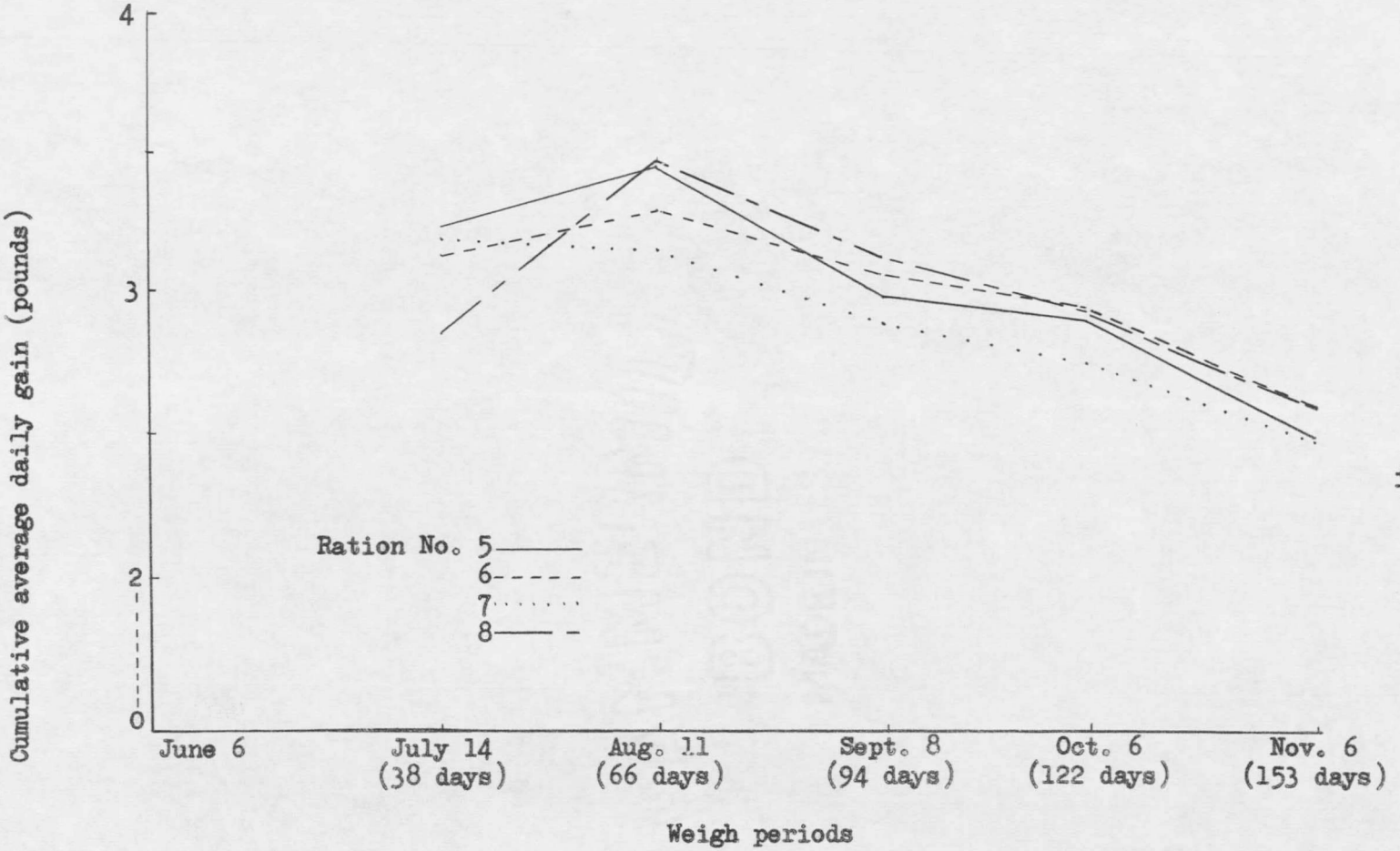

Figure 4. Cumulative Average Daily Gain by Weigh Period for Steers in Trial II.

Feed consumption. The average daily feed consumption as shown in Table XIII indicated that lot 5 steers, fed steam-rolled barley plus five pounds of hay, consumed the most feed, 22.23 pounds per animal daily. The steers in lot 8, fed steam-rolled barley with no hay, consumed the least total feed, 20.68 pounds per head daily. The animals in lot 7, fed steam-rolled barley, consumed about one-half pound more barley per head daily than the lot 6 steers that received dry-rolled barley.

The feed consumed by the cattle in lots 5 and 7 increased the first two weigh periods and then decreased during the third and fourth weigh periods. The cattle in lots 6 and 8 reached their peak in feed consumption the third weigh period and then decreased during the fourth weigh period. There was an increase in total feed consumption by all cattle during the final weigh period. The weather was cooler during the last weigh period and may have caused this increase in feed consumption.

As the roughage level was increased in the ration, the total feed consumed by the steers also increased. The barley consumption decreased as the level of hay in the ration increased, but there was not a corresponding decrease in barley consumption.

Feed efficiency. Table XIII shows the steers fed steam-rolled barley with no hay (lot 8) had the best feed efficiency. They required 798.64 pounds of feed per hundredweight gain. The animals that received steam-rolled barley plus five pounds of hay per steer daily (lot 5) had the poorest feed efficiency of 896.44 pounds of feed per one hundred

pounds of gain. The animals in lot 6, fed dry-rolled barley plus two pounds of hay, required an average of about 60 pounds of feed less per one hundred pounds of gain than the steers in lot 7, fed steam-rolled barley plus two pounds of hay.

The cattle in lots 5, 6, and 7 had a steady decrease in feed efficiency during the first three weigh periods. Lot 8 steers had an increased feed efficiency the second weigh period, followed by a decrease during the third weigh period. All steers were more efficient the fourth weigh period than the third weigh period. There was a large increase in feed required per hundredweight gain by cattle in all lots the last weigh period.

Feed costs. Table XIII shows that feed costs per hundred pounds of gain were highest ($18.60) for steers in lot 7, fed steam-rolled barley plus two pounds of hay. Feed costs per one hundred pounds of gain were lowest ($17.27) for the lot 6 steers, fed dry-rolled barley plus two pounds of hay per animal daily. The feed costs per one hundred pounds of gain for steers in lot 5, fed steam-rolled barley plus about five pounds of hay per animal daily, were $18.11. Lot 8 steers, fed steam-rolled barley with no hay, had a feed cost of $17.78 to produce one hundred pounds of gain.

Carcass data. The cattle were sold on a carcass-grade basis of $37.50 per hundredweight for choice and $36.50 per hundredweight for good. All groups of steers gave a positive financial return except the lot 5 steers, which lost $4.08 per steer. This loss was largely a result of

the lower carcass grades of the lot 5 steers compared with the other steers (Table XIII). All cattle in lots 6, 7, and 8 graded choice. Four cattle graded choice and four graded good in lot 5.

There were ten livers condemned at the time of slaughter. Abscesses were the predominant cause for condemning the livers. Following is the number of livers condemned per lot: lot 5, four; lot 6, three; lot 7, one, and lot 8, two condemned livers.

Examination of rumen samples revealed that most of the rumens of lot 8 cattle were gray to black in color. Some of the rumen samples from lot 8 cattle showed localized areas of clumped and crusted papillae. There were also areas of depapillation present. The rumen samples from cattle in lots 5, 6, and 7 were light in color and did not show any abnormal variation in physical characteristics of the rumen papillae. None of the rumen samples showed severe cases of rumen parakeratosis.

Table XIV shows that the average final weight and the carcass weight

TABLE XIV. CARCASS WEIGHTS AND DRESSING PERCENTAGE FOR STEERS FED STEAM-ROLLED AND DRY-ROLLED BARLEY (TRIAL II).

Lot and ration number	5	6	7	8
Avg. final wt. (lb.)	1104	1136	1093	1124
Avg. warm carcass wt. (lb.)	659	689	671	680
Avg. cold carcass wt. (lb.) (2.5% shrink)	643	672	654	663
Avg. dressing percentage (warm wt. basis)	59.7	60.7	61.4	60.5
Avg. dressing percentage (cold wt. basis)	58.2	59.2	59.8	59.0

were highest for the steers fed ration 6, dry-rolled barley plus two pounds of hay. The steers in lot 7, fed steam-rolled barley plus two pounds of hay, had the highest dressing percentage. The lot 5 steers, which received the highest level of hay, had the lowest carcass weight and lowest dressing percentage. The steers in lots 6 and 8 had about equal dressing percentages.

Summary. Lots 6 and 8 steers, fed dry-rolled barley plus two pounds of hay per animal daily and steam-rolled barley with no hay, performed better than the lots 5 and 7 steers, fed steam-rolled barley plus five and two pounds of hay respectively. The animals in lots 6 and 8 had the highest average daily gain (2.59 pounds) and the best feed efficiency. The lot 6 steers had the lowest feed cost per hundredweight gain and the highest net return of any of the groups of steers. The lot 5 animals had the poorest feed efficiency, lowest carcass grade, and the lowest net return. Five pounds of hay per steer daily was too high for maximum rate and economy of gain. Foot rot in the lot 7 steers undoubtedly contributed to their decreased performance. The steers fed an all-concentrate ration after the first three weeks of the trial (lot 8) performed as well as any of the other steers.

Comparison of Trials I and II

A comparison of the results of trial I and trial II was difficult because of weather differences and variability of experimental animals. There were, however, results which were common to both trials as well as differences in the results.

Figure 5 shows a comparison of average daily gain of trial I and trial II steers. The graph shows that steers in both trials reached their peak in average daily gain the second weigh period. The average daily gain decreased the remainder of the experiment for trial I steers. This was generally true for trial II steers with the exception of a slight increase in average daily gain the fourth weigh period.

The cumulative average daily gain for the trials I and II steers is shown in Figure 6. The trial II steers had a consistently higher cumulative average daily gain than the trial I steers. This was probably due, in part, to the fact that the trial II steers weighed less than the trial I steers. Weather conditions may have caused some of the difference in gain among the steers. The trial I steers fed during the winter needed more energy to supply body heat than the trial II steers. The lower level of hay fed the steers in lot 5 (trial II), compared with the lot 1 steers (trial I), also contributed to the difference in average daily gain among steers on the two trials. It is of interest that the difference in cumulative average daily gain between the steers on the two trials was approximately constant throughout the feeding period. This would indicate that the factors responsible for the differences in gain probably remained relatively constant in their effect throughout the trials.

The average daily feed consumption was higher for the trial I steers than for the trial II steers. The heavier weight of the trial I steers probably caused much of the difference. Also, the summer heat undoubtedly depressed the feed consumption of the trial II steers. The cold weather

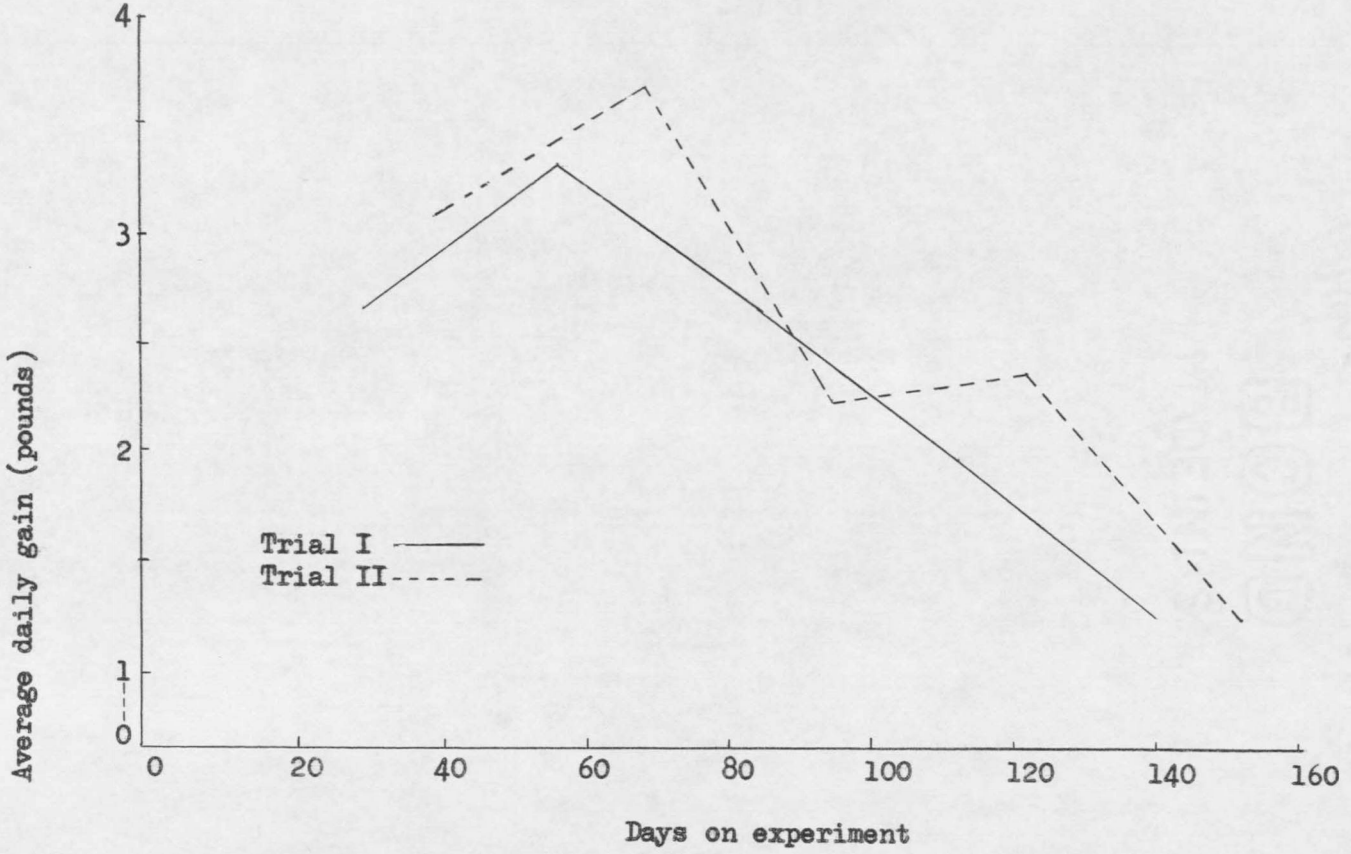

Figure 5. A Comparison of the Average Daily Gain of Trial I and Trial II Steers.

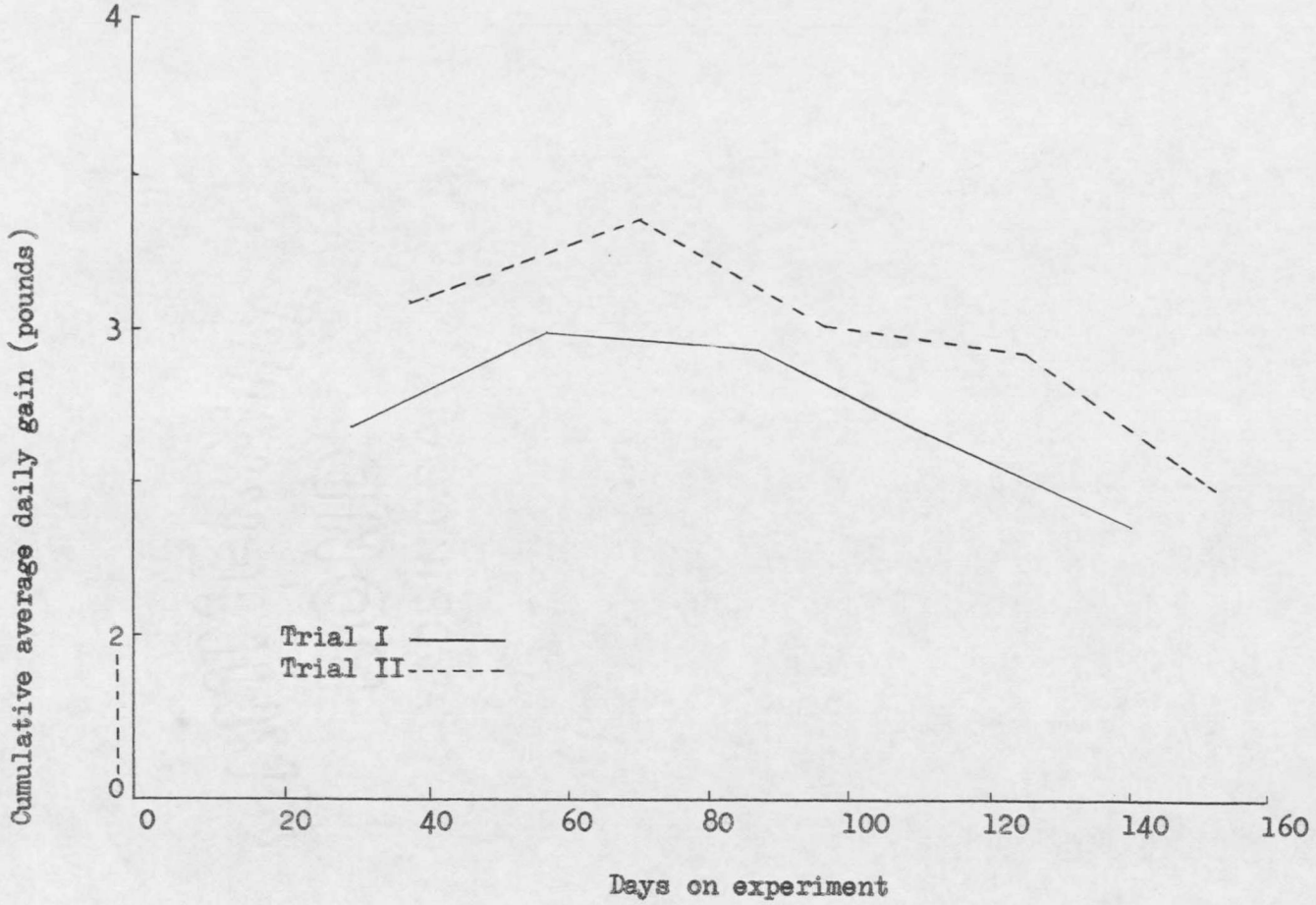

Figure 6. A Comparison of the Cumulative Average Daily Gain of Trial I and Trial II Steers.

during trial I may have caused an increase in feed consumption by these steers. The steers needed more feed as a source of energy to produce the additional body heat required during cold weather. The animals fed steam-rolled barley without hay (lots 3 and 8) consumed the least feed per animal daily and had the best efficiency. The steers fed the highest levels of hay (lots 1 and 5) in both trials consumed the most feed and had the lowest feed efficiency of any of the other groups of steers.

The results were contrary when comparing steam-rolled and dry-rolled barley with two pounds of hay in the two trials. The steers fed steam-rolled barley had a slightly better feed efficiency and lower feed costs than the steers fed dry-rolled barley in trial I. In trial II, the steers fed dry-rolled barley had the best gain and feed efficiency and the lowest feed costs. In general, there was not a marked difference in steer performance due to preparation of the barley.

There was little difference in performance between steers fed two pounds of hay per animal daily and steers fed an all-concentrate ration. The steers fed steam-rolled barley plus five and six pounds of hay per head daily did not perform as well as the other steers.

Wintering Trial

Forty-eight weaned Hereford calves, which averaged 442 pounds initially, were used in the 84-day wintering trial. There was a difference of about 30 pounds in average initial and final weight between the lightest and heaviest group of calves. Average final weight of the steers was 586 pounds. Individual initial and final weights and average daily gains are shown in Appendix Table X.

Weight gains. There was only 0.05 of a pound difference in average daily gain among the four groups of calves, as shown in Table XV. This difference in average daily gain was not statistically significant.

The average daily gain is shown by weigh periods in Figure 7. All calves gained less weight during the second weigh period than during the first. The lots 1 and 2 calves, fed steam-rolled barley and steam-rolled barley with molasses, had about the same average daily gain by weigh periods during the trial. The calves in lots 3 and 4, fed steam-rolled barley with molasses and dry-rolled barley respectively, had the best gain the second weigh period but gained less during the third weigh period than the calves in lots 1 and 2.

Lots 1, 2, and 3 steers had about the same cumulative average daily gain during the trial (Figure 8). All steers decreased in cumulative average daily gain during the second weigh period. The lot 4 steers, fed dry-rolled barley, had a higher cumulative average daily gain the first two weigh periods than the other groups of steers. The lot 4 calves decreased in cumulative average daily gain during the third weigh period while all other groups of calves increased.

Six calves in each lot were sired by Individual Performance Record bulls and six calves were from untested sires. Only five certified steers and five other steers per lot are used for all comparisons because one certified steer in each lot is from a different group of cows than are the other five certified steers. Table XVI shows a comparison of average daily gain and cumulative average daily gain between certified

TABLE XV. SUMMARY OF WEIGHT GAINS, FEED CONSUMPTION, FEED CONVERSION, AND FINANCIAL RETURNS FOR WINTERING TRIAL.

Lot and ration number	1	2	3	4
Treatment/steer daily				
Barley, rolled	steam	steam + molasses	steam + molasses + celluade	dry
Mixed grass-alfalfa hay 1/	X	X	X	X
Avg. wts. (lb.)				
Initial	460	433	445	428
Final	607	578	588	571
Gain	147	145	143	143
Daily gain	1.75	1.73	1.70	1.70
Avg. daily ration (lb.)				
Barley	3.65	3.65	3.65	3.65
Supplement	1.90	1.90	1.90	1.90
Hay	8.05	8.05	8.05	8.05
Mineral	0.10	0.10	0.10	0.10
Total	13.70	13.70	13.70	13.70
Feed/cwt. of gain (lb.)	783	791	810	808
Feed cost/cwt. of gain ($) 2/	13.24	13.70	14.45	13.66
Total feed cost/steer for wintering trial ($)	19.46	19.86	20.65	19.53

1/All cattle received a full feed of hay.
2/Feed prices: mixed hay, $23/ton; mineral, $4.38/cwt.; protein supplement (lots 1, 2, and 4), $57.26/ton; protein supplement (lot 3), $64.52/ton; barley (steam-rolled and dry-rolled), $47/ton; steam-rolled barley plus 5% molasses, $47/ton.

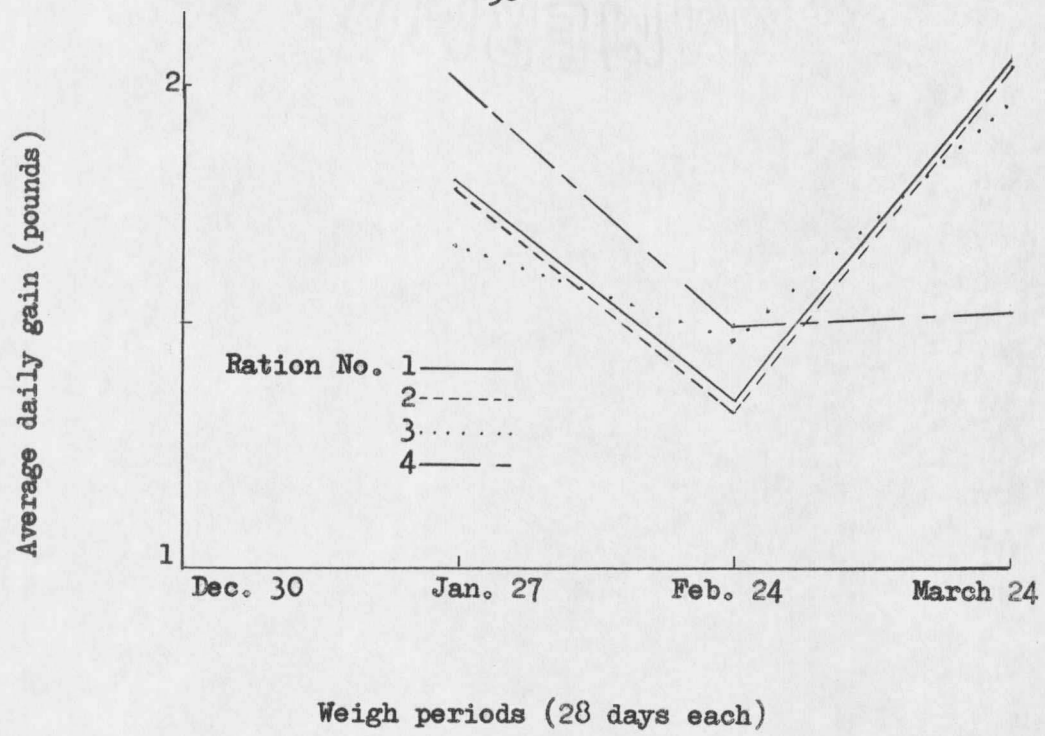

Figure 7. Average Daily Gain by Weigh Period for Steers Fed A Restricted Ration (Wintering Trial).

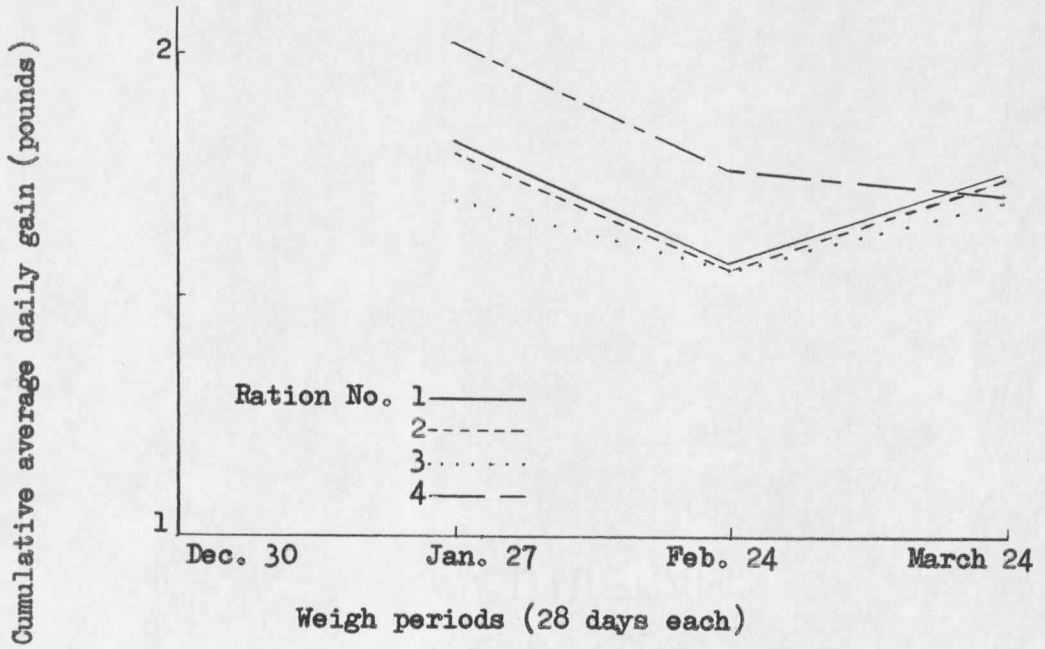

Figure 8. Cumulative Average Daily Gain by Weigh Period for Steers on Wintering Trial.

TABLE XVI. A COMPARISON OF AVERAGE DAILY GAIN AND CUMULATIVE DAILY GAIN IN POUNDS BETWEEN CERTIFIED STEERS AND STEERS FROM UNTESTED SIRES (WINTERING TRIAL).

Lot and ration number		Weigh periods					
		Dec. 30 - Jan. 26		Jan. 27 - Feb. 23		Feb. 24 - March 24	
		Avg. daily gain	Cumulative avg. daily gain	Avg. daily gain	Cumulative avg. daily gain	Avg. daily gain	Cumulative avg. daily gain
		lb.	lb.	lb.	lb.	lb.	lb.
1.	A. 1/	1.86	1.86	1.32	1.59	2.21	1.80
	B. 2/	1.75	1.75	1.50	1.62	2.14	1.80
2.	A.	1.71	1.71	1.46	1.59	1.96	1.71
	B.	1.82	1.82	1.07	1.45	2.00	1.63
3.	A.	1.50	1.50	1.64	1.57	1.89	1.68
	B.	1.93	1.93	1.21	1.57	1.89	1.68
4.	A.	2.00	2.00	1.61	1.80	1.71	1.77
	B.	1.96	1.96	1.36	1.66	1.32	1.55

1/Five certified steers.
2/Five steers from untested sires.

steers and steers from untested sires. The certified steers in lots 2 and 4, fed steam-rolled barley plus molasses and dry-rolled barley, made slightly better gains than the other steers in the same lots. The daily gain was about the same for both groups of steers in lots 1 and 3, fed steam-rolled barley and steam-rolled barley plus molasses and celluade, respectively. The average daily gain for all the certified steers was 0.06 of a pound greater than the other steers for the wintering trial (Table XVIII). There were no statistically significant differences in average daily gain betweeen the certified steers and the other steers.

Feed consumption. All calves were fed a restricted level of barley during the experiment. The average daily feed intake per steer was 13.70 pounds, as shown in Table XV. Each animal consumed an average of 8.05 pounds of mixed alfalfa-grass hay and 3.65 pounds of barley per day during the trial. The feed was gradually increased until each animal consumed 15.5 total pounds of feed daily during the last weigh period. The barley level was gradually increased during the trial while the hay level remained about the same.

Feed efficiency. There was a difference of only 27 pounds of feed required per 100 pounds of gain between the most efficient group of steers (lot 1) and the least efficient steers (lot 3), as shown in Table XV. Lots 1, 2, and 3 steers were most efficient the first weigh period and least efficient the second weigh period. The feed efficiency of lot 4 steers progressively decreased during the trial.

Feed costs. The feed cost per 100 pounds of gain was over one dollar less for the lot 1 steers compared with the lot 3 steers (Table XV). The addition of ten percent celluade to the protein supplement fed the lot 3 steers resulted in a higher feed cost than for the other groups of steers. The lots 2 and 4 calves had about the same feed cost per 100 pounds of gain.

Summary. In the wintering trial, there were only small differences in results among the four groups of calves. This would indicate there was little difference in the feeding value of barley, steam-rolled, dry-rolled, or steam-rolled with five percent molasses added, when fed at a restricted level in equal quanitity to all steers.

The steers fed rations 1 and 2 (steam-rolled barley and steam-rolled barley with molasses) gained more weight and were more efficient than the other two groups of steers. Lot 1 steers gave slightly better results than lot 2 steers in all aspects of the trial. The lot 3 steers, fed steam-rolled barley plus molasses and celluade, were least efficient and had higher feed costs than the other three groups of steers. However, there were little differences in the results of lots 3 and 4 steers.

Fattening Trial

The 48 Hereford calves on the wintering trial were used in a 179-day fattening experiment. The average final weight of 588 pounds per steer on the wintering trial was used as the average intital weight for the fattening period. Individual initial and final weights and average daily gains are shown in Appendix Table XVII.

Weight gains. The lot 1 steers, fed steam-rolled barley, had the best average daily gain of 2.56 pounds, as shown in Table XVII. The lot 4 steers, fed dry-rolled barley, had the lowest average daily gain of 2.37 pounds. The average daily gain of the lots 2 and 3 steers, fed steam-rolled barley with molasses and steam-rolled barley with molasses and celluade, was 2.42 and 2.46 pounds respectively. These differences in average daily gains were not statistically significant.

Weight gains of steers by weigh periods are shown in Figure 9. There was an increase in daily gain the second and third weigh periods by steers in lots 1, 3, and 4. Steers in lot 1 had an increase in daily gain the second weigh period, followed by a decrease the third and fourth weigh periods. All steers decreased at least one pound in average daily gain during the fourth weigh period. This decrease may have been partially due to the hot weather during this weigh period. The average daily gain of the steers the last three weigh periods was irregular. There was a net loss of weight by lots 1, 2, and 3 steers the last weigh period (13 days), because of the 16-hour shrink given the steers before final weights were recorded.

The cumulative average daily gain by weigh periods is shown in Figure 10. All steers increased in cumulative daily gain during the second and third weigh periods, followed by a gradual decrease the remainder of the trial. The lot 1 steers, fed steam-rolled barley, had the best cumulative average daily gain during most of the trial. The lot 4 steers, fed dry-rolled barley, had the lowest cumulative average daily gain after the first weigh period.

TABLE XVII. SUMMARY OF WEIGHT GAINS, FEED CONSUMPTION, FEED EFFICIENCY, AND FEED COSTS FOR FATTENING TRIAL.

Lot and ration number	1	2	3	4
Treatment/steer daily				
Barley, rolled	steam	steam + molasses	steam + molasses + celluade	dry
Hay (lb.)	2	2	2	2
Steers/lot	12	11 1/	12	11 1/
Avg. wts. (lb.)				
Initial	607	581	588	574
Final	1066	1015	1029	998
Gain	459	434	441	424
Daily gain	2.56	2.42	2.46	2.37
Avg. daily ration (lb.)				
Barley	16.91	16.17	16.34	15.15
Supplement	1.00	1.00	1.00	1.00
Hay	2.85	2.90	2.85	2.86
Salt and mineral	0.09	0.09	0.07	0.07
Total	20.85	20.16	20.26	19.08
Feed/cwt. of gain (lb.)				
Barley	658.70	670.00	662.70	636.20
Supplement	38.90	41.50	40.60	42.10
Hay	110.80	120.10	115.60	120.00
Salt and mineral	3.61	3.80	3.28	3.41
Total	812.01	835.40	822.18	801.71
Feed cost/cwt. of gain ($) 2/	16.95	18.39	18.53	16.66

1/One steer in lot 2 removed because of bloat after 67 days on feed. One steer died in lot 4 after 173 days on trial. Gains of these steers were included in calculating feed consumed per 100 pounds of gain.

2/Feed prices: mixed hay, $23/ton; mineral, $4.38/cwt.; protein supplement (lots 1, 2, and 4), $55.55/ton; protein supplement (lot 3), $74.98/ton; barley (steam-rolled and dry-rolled), $47/ton; steam-rolled barley plus 5% molasses, $47/ton.

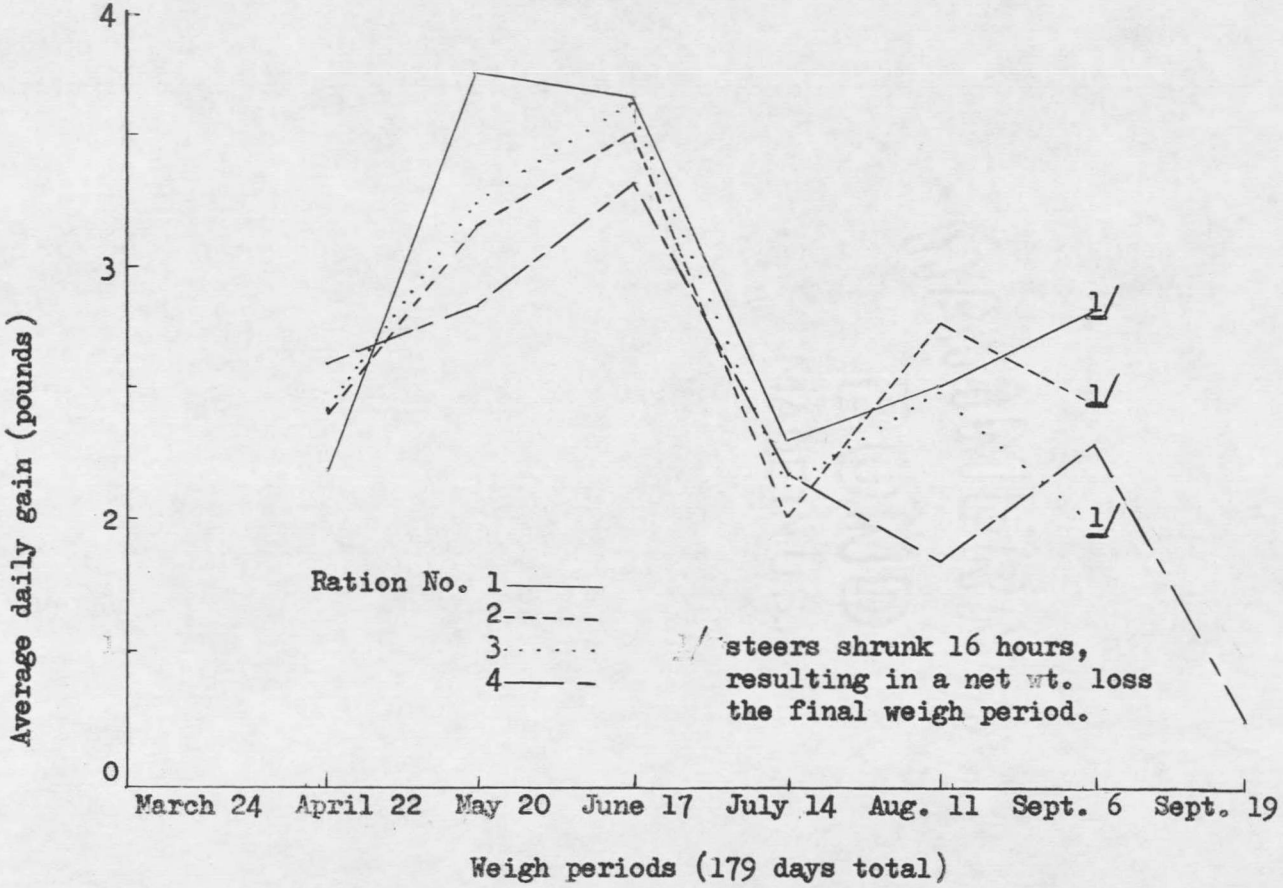

Figure 9. Average Daily Gain by Weigh Period for Steers on Fattening Trial.

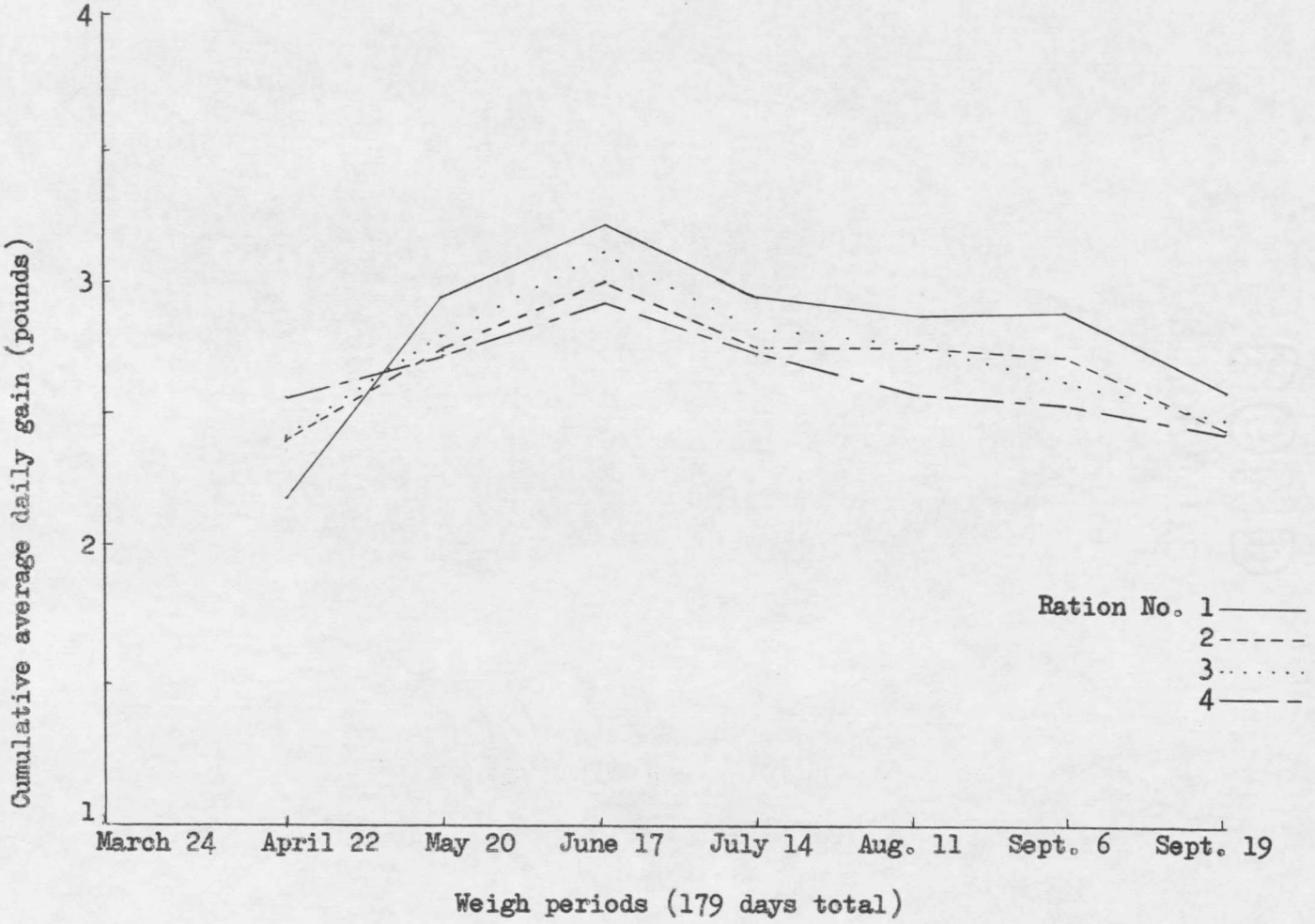

Figure 10. Cumulative Average Daily Gain by Weigh Period for Steers on Fattening Trial.

The certified steers in lots 2 and 3 had a higher average daily gain all weigh periods than the steers from untested sires in those lots. The certified steers had a higher average daily gain than the other steers every weigh period except the third in lot 1. In lot 4, the certified steers had the highest average daily gain four of the seven weigh periods. There was a highly significant difference ($P < 0.01$) in average daily gain within lots between the certified steers and the other steers.

A comparison of average daily gain by weigh period with the certified steers and the steers from untested sires is shown in Figure 11. The certified steers had a higher average daily gain every weigh period during the fattening trial. The difference in average daily gain by weigh period varied between 0.2 and 0.6 of a pound.

The cumulative average daily gain by weigh period was also higher for the certified steers (Figure 12). There was a constant difference in daily gain of 0.3 to 0.5 of a pound between the certified steers and the other steers.

The total average daily gain for the certified steers was 2.62 pounds, whereas the steers from untested sires had a total average daily gain of 2.23 pounds (see Table XVIII). This difference of 0.39 pounds was highly significant ($P < 0.01$).

Feed consumption. The average daily feed consumption was highest for the lot 1 steers, fed steam-rolled barley, and lowest for the lot 4 steers, fed dry-rolled barley (Table XVII). The lots 1 and 4 steers also

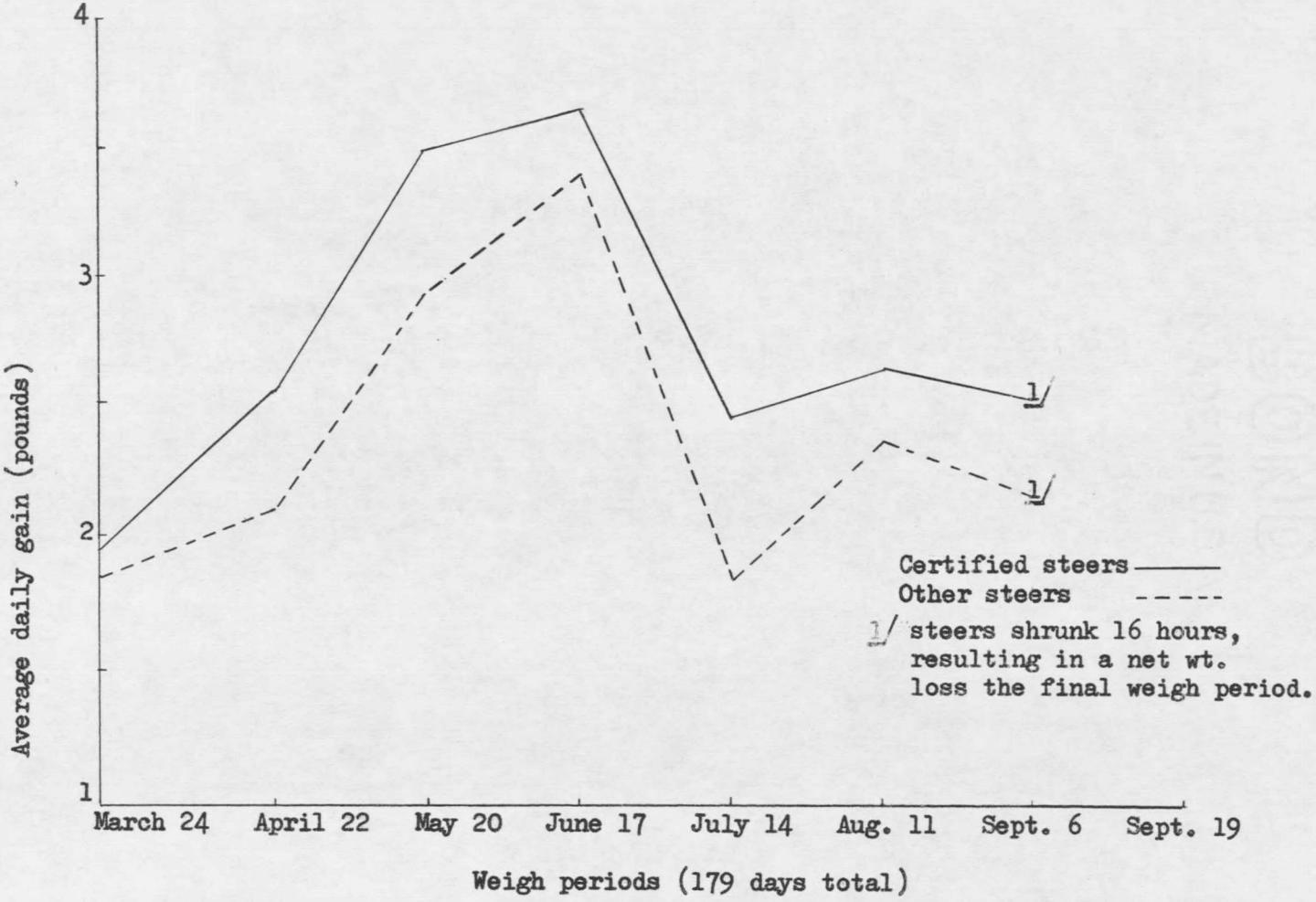

Figure 11. A Comparison of Average Daily Gain by Weigh Period of Certified Steers and Steers from Untested Sires (Fattening Trial).

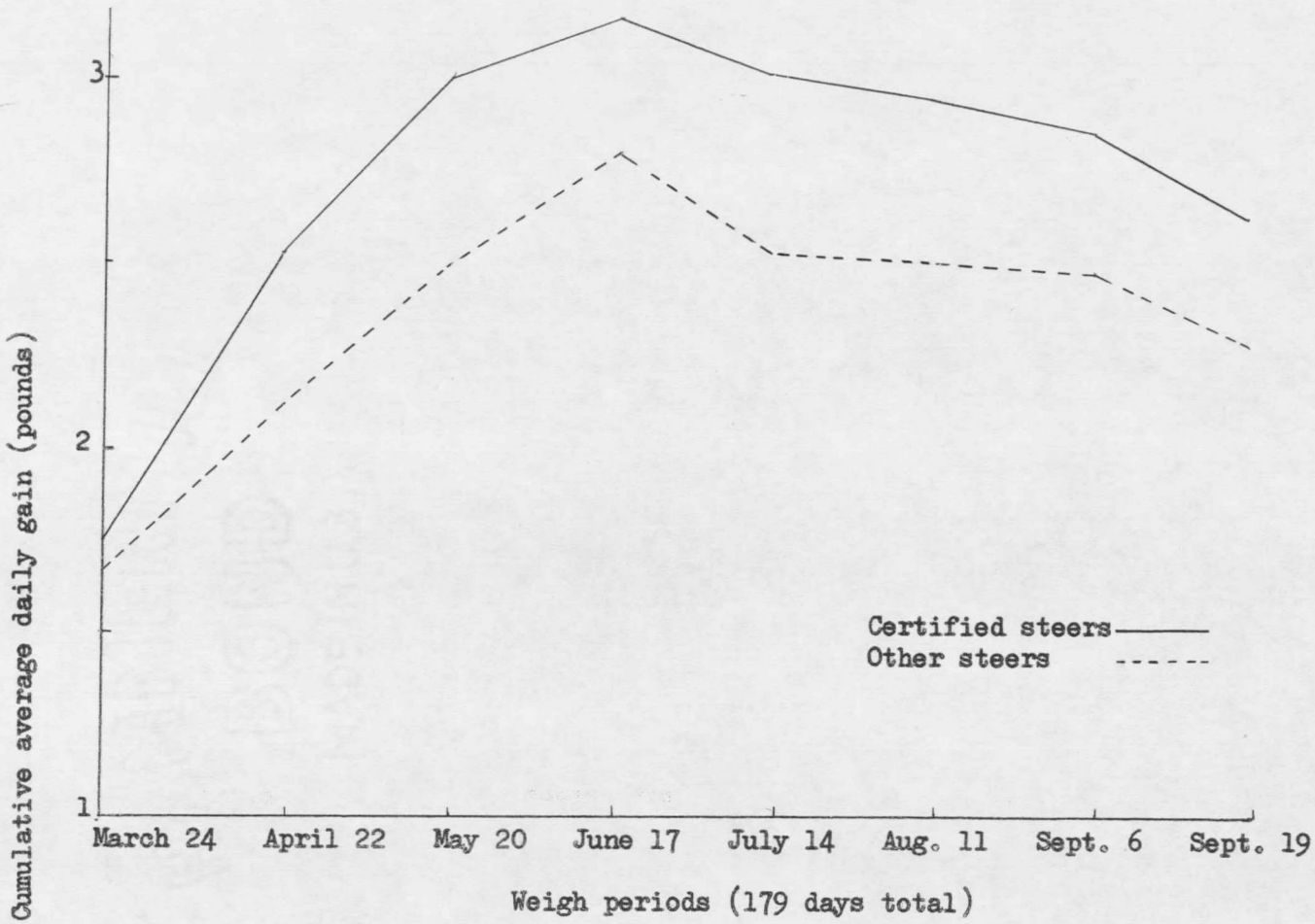

Figure 12. A Comparison of Cumulative Average Daily Gain by Weigh Period of Certified Steers and Steers from Untested Sires (Fattening Trial).

had the highest and lowest barley consumption respectively. The feed consumption of the lots 2 and 3 steers, fed steam-rolled barley with molasses and steam-rolled barley with molasses and celluade respectively, was about the same.

TABLE XVIII. AVERAGE WEIGHT AND GAINS OF CERTIFIED AND NON-CERTIFIED STEERS.

	No. of steers	Initial wt. lb.	Final wt. lb.	Total gain lb.	Daily gain lb.
Wintering trial					
Certified steers	20	429	574	146	1.73
Non-certified steers	20	440	579	139	1.67
Fattening trial					
Certified steers	19	576	1044	468	2.62
Non-certified steers	19	581	980	399	2.23
Total (wintering and fattening trials)					
Certified steers	19	431	1044	613	2.33
Non-certified steers	19	442	980	538	2.04

Steers in all lots increased in average daily feed consumption the first three weigh periods, followed by a decrease the fourth weigh period. The feed consumption for all steers was about equal the fifth and sixth weigh periods and was above the feed consumption for the fourth weigh period. Feed consumption decreased for all steers the last weigh period. The lot 1 steers had the highest feed consumption all weigh periods except the first and fourth, whereas the lot 4 steers had the lowest feed consumption during most of the feeding period. The heavier weight of the lot 1 steers compared with the other three groups of steers would partially account for the higher feed consumption of the lot 1 steers.

However, the steers in lot 1 had a slightly higher daily feed consumption than the lot 4 steers, based on a percentage of their live weight. The feed consumption of lots 1, 2, and 3 steers was about the same when based on a percentage of the average live weight of the animal.

Feed efficiency. There was little difference in the pounds of feed required per hundredweight gain among the four groups of steers (see Table XVII). The feed efficiency was best for the lot 4 steers, fed dry-rolled barley. The lot 1 steers, fed steam-rolled barley, required about ten pounds of feed more per 100 pounds of gain than the lot 4 steers. The lot 3 steers, fed steam-rolled barley plus molasses and celluade, were slightly more efficient than the lot 2 steers, fed steam-rolled barley plus molasses.

The feed efficiency for all steers was about the same the first three weigh periods. There was an increase by all steers of 250 to 400 pounds of feed required per 100 pounds of gain during the fourth weigh period. As would be expected, this decrease in feed efficiency occurred the same weigh period as a decrease in average daily gain.

The feed efficiency of cattle in lots 1 and 2 increased the fifth and sixth weigh periods. This increase also corresponded to an increase in daily gain during the fifth and sixth weigh periods. The feed efficiency of the lots 3 and 4 steers was irregular, as was their daily gain during the fifth and sixth weigh periods. The feed efficiency of lots 1, 2, and 3 steers the last weigh period (13 days) could not be calculated because of a net loss in weight. The lot 4 steers gained only

0.49 of a pound per head daily the seventh weigh period and, therefore, had a poor feed efficiency.

Feed costs. A feed cost of $16.66 per 100 pounds of gain for the lot 4 steers (dry-rolled barley) was the lowest of the four groups of steers (Table XVII). The lot 3 steers, fed steam-rolled barley plus molasses and celluade, had the highest feed cost of $18.53 per 100 pounds of gain. The feed cost per 100 pounds of gain for the lots 1 and 2 steers, fed steam-rolled barley and steam-rolled barley with molasses, was $16.95 and $18.39 respectively. The calves fed steam-rolled and dry-rolled barley (lots 1 and 4) had a feed cost per 100 pounds of gain of about $1.50 less than the calves fed steam-rolled barley with molasses and steam-rolled barley with molasses and celluade (lots 2 and 3).

Carcass data. The carcass grades of the lots 2, 3, and 4 steers were about the same, as shown in Table XIX. One steer in each of the three lots graded good and the remainder of the steers graded choice. There were three steers in lot 1 that graded good and nine that graded choice.

Rumen samples taken at the time of slaughter revealed that rumens of cattle fed steam-rolled barley with molasses (lots 2 and 3) were consistently gray to black in color with unusually long papillae. Some of the rumens of lots 2 and 3 cattle also showed areas of clumped and hardened papillae. The rumen samples of cattle fed steam-rolled and dry-rolled barley (lots 1 and 4) were pinkish to gray in color and appeared to be normal in every respect. There did not seem to be any

correlation between the physical characteristics of the rumen and steer performance.

TABLE XIX. FINANCIAL RETURNS AND CARCASS GRADES FOR STEERS ON FATTENING EXPERIMENT.

Lot and ration number	1	2	3	4
Treatment/steer daily				
Barley, rolled	steam	steam + molasses	steam + molasses + celluade	dry
Hay (lb.)	2	2	2	2
Financial return/steer ($)				
Initial cost 1/	141.59	135.62	138.80	133.96
Feed cost	77.80	79.81	81.72	70.64
Trucking charge	2.31	2.31	2.31	2.31
Total investment 2/	221.70	217.74	222.83	206.91
Gross return 3/	231.16	233.73	229.13	220.04
Net return	9.46	16.00	6.30	13.13
Carcass grades				
Choice	9	10	11	11
Good	3	1	1	1

1/Initial cost of $26.55/cwt. November 12, 1960, plus feed cost for wintering shown in Table XV. Steers lost from experiment were not used in calculating initial cost or gross returns.
2/Labor costs excluded.
3/Steers were sold on a carcass-grade basis: choice, $37.50/cwt. and good, $36.50/cwt.

There were ten condemned livers: one from lot 1 steers, five from lot 2 steers, two from lot 3 steers, and two from lot 4 steers.

The lot 2 steers had a dressing percentage of 63.2, based on the warm carcass weight. This was over two percent higher than the next highest group of steers (lot 3). It is believed that there may have been an error in the final weight or the warm carcass weight of one lot 2 steer which had a dressing percentage (warm-weight basis) of 72.6. The steers fed steam-rolled and dry-rolled barley (lots 1 and 4) had

about the same dressing percentage of 58.0 and 58.9 respectively (see Table XX).

TABLE XX. CARCASS WEIGHTS AND DRESSING PERCENTAGES FOR STEERS ON THE FATTENING TRIAL.

Lot and ration number	1	2	3	4
Avg. final wt. (lb.)	1066	1015	1029	998
Avg. warm carcass wt. (lb.)	633	641	628	603
Avg. cold carcass wt. (lb.) 1/	618	625	613	588
Avg. dressing percentage (warm wt. basis)	59.4	63.2 2/	61.0	60.4
Avg. dressing percentage (cold wt. basis)	58.0	61.6	59.6	58.9

1/A 2.5% shrink from warm carcass weight.
2/A steer in this lot had a dressing percentage of 72.6, based on the warm carcass weight. An error may have been made either in the final weight or the warm carcass weight.

The steers were sold on a carcass-grade basis of $37.50 per hundredweight for choice and $36.50 per hundredweight for good. All steers gave a positive financial return, as shown in Table XIX. Lot 2 steers returned $16.00 per steer over feed cost; this return was greater than that for steers in any other lot. The steers in lot 4, fed dry-rolled barley, returned $13.13 per head. These calves were most efficient during the trial. This feed efficiency was largely responsible for the lot 4 steers having the second highest net return. The lot 3 steers had the lowest net return of $6.30 per steer. The net return was $9.46 per steer for the lot 1 steers.

Summary. The results of this trial indicate that there is little difference in the value of steam-rolled barley, steam-rolled barley with

molasses, and dry-rolled barley when fed with two pounds of hay and one pound of a protein supplement to fattening steers. The addition of ten percent celluade to the protein supplement did not improve the performance of the cattle.

The steers fed steam-rolled barley had the best daily gain and the highest feed consumption, whereas the steers fed dry-rolled barley consumed the least feed and had the best feed efficiency. The lot 2 steers, fed steam-rolled barley with molasses, had the highest dressing percentage and net return of any of the steers.

There was a highly significant difference ($P < 0.01$) of 0.4 of a pound in average daily gain, with the certified steers gaining faster than the steers from untested sires during the fattening trial (see Table XVIII). The average daily gain was 0.3 of a pound greater for the certified steers during both the wintering and fattening period. This difference in daily gain of the certified steers and the steers from untested sires could determine a profit or a loss to the feedlot operator.

SUMMARY AND CONCLUSIONS

Two similar fattening experiments (trial I and trial II) were conducted with yearling Hereford steers to compare the fattening value of steam-rolled and dry-rolled barley when fed with varying levels of hay.

A wintering trial and a fattening trial with Hereford steers were conducted to compare the feeding value of steam-rolled barley, steam-rolled barley with molasses, and dry-rolled barley. The barley was fed at a restricted level with a full feed of hay during the wintering trial. A full feed of barley and two pounds of hay per steer daily were fed during the fattening trial. The performance of certified steers was compared with the performance of steers from untested sires during the wintering and fattening trials. Celluade was fed during the wintering and fattening trials.

There were few consistent differences in the performance of steers fed steam-rolled or dry-rolled barley with two pounds of hay. In trial I, the steers fed steam-rolled or dry-rolled barley with two pounds of hay had the same average daily gain. However, in trial II, the steers fed dry-rolled barley gained about 0.10 of a pound per day more than the steers fed steam-rolled barley. The steers fed steam-rolled barley had an average daily gain of almost 0.2 of a pound more than the steers fed dry-rolled barley during the 179-day fattening trial.

The daily feed consumption of steers fed dry-rolled barley plus two pounds of hay was lower than the feed consumption of steers fed steam-rolled barley plus two pounds of hay in two of the three fattening trials. The feed efficiency was also better for the steers fed dry-rolled

barley in the same two fattening trials. The steers fed steam-rolled barley were more efficient than steers fed steam-rolled barley with molasses or dry-rolled barley when a restricted level of barley and a full feed of hay were fed (wintering trial).

The carcass grades of cattle fed steam-rolled or dry-rolled barley were about the same (trials I and II). All groups of steers fed dry-rolled barley with two pounds of hay had a higher net return than the steers fed steam-rolled barley with two pounds of hay.

In general, steam-rolled or dry-rolled barley with two pounds of hay and a supplement gave about the same results when fed to fattening cattle. Factors such as personal preference, availability, and economics will probably determine which form of barley to feed.

Cattle fed steam-rolled barley plus five or six pounds of hay had poorer gains, feed efficiency, and net returns than cattle fed barley plus either two pounds of hay or no hay (trials I and II). The carcass grades of steers fed five pounds of hay in trial II were lower than the carcass grades of the other groups of trial II steers. However, this was not true for the trial I steers. The results of trials I and II indicated that cattle fed barley plus no hay or two pounds of hay and a protein supplement performed better than steers fed barley plus five or six pounds of hay per head daily.

Cattle fed an all-concentrate ration (trials I and II) consumed less total feed and were more efficient than steers fed two or six pounds of hay. The average daily gain of steers fed an all-concentrate ration was 0.13 of a pound less than the average daily gain of steers fed two pounds

of hay in trial I. The average daily gain of the steers fed an all-concentrate ration in trial II was the same as the steers fed dry-rolled barley plus two pounds of hay and 0.12 of a pound higher than the steers fed steam-rolled barley plus two pounds of hay.

The rumen samples of the steers fed an all-concentrate ration were generally darker in color than the rumens of steers fed either two or six pounds of hay. Some rumens of cattle fed an all-concentrate ration were characterized by elongated and crusted papillae with small areas of depapillation present.

The cattle fed an all-concentrate ration generally performed as well and had a net return as high as steers fed two pounds of hay per head daily. The results of trials I and II indicate that cattle may be fattened competitively using an all-concentrate ration, properly supplemented with protein, minerals, and vitamins.

There was little difference in average daily gain or feed consumption between steers fed steam-rolled barley plus molasses and steam-rolled barley or dry-rolled barley on a 179-day fattening trial. The steers fed steam-rolled barley plus molasses had a poorer feed efficiency and a higher total feed cost than steers fed steam-rolled or dry-rolled barley. The addition of celluade to the ration of steers fed steam-rolled barley plus molasses did not improve steer performance.

Steers sired by performance tested bulls gained faster than steers sired by untested bulls during the wintering and fattening trials. There was a difference of 0.06 of a pound in average daily gain during the wintering trial. There was a highly significant difference ($P < 0.01$)

of 0.4 of a pound in average daily gain between the certified steers and the other steers during the fattening trial. The certified steers had an average daily gain of 0.3 of a pound greater than the steers sired by untested bulls during the wintering and fattening trials.

There was little difference in the performance of Hereford steers fed an all-concentrate ration or two pounds of hay plus steam-rolled barley, steam-rolled barley with molasses, or dry-rolled barley. Steers fed steam-rolled barley plus five or six pounds of hay gave poorer results than steers that received steam-rolled barley with no hay or two pounds of hay.

APPENDIX

APPENDIX TABLE I. SPECIFICATIONS FOR THE CELLUADE ADDED TO THE PROTEIN SUPPLEMENT FED LOT 3 STEERS DURING THE WINTERING AND FATTENING TRIALS. 1/

Ingredients	Percent
Protein	24.00
Fat	3.70
Fiber	7.40
TDN	74.00
Calcium	0.24
Phosphorus	0.69
Manganese	0.610
Iodine	0.012
Cobalt	0.003
Iron	0.220
Copper	0.025
Zinc	0.017
Vitamin A, U. S. P. units/pound	56,750
Vitamin D, I. C. units/pound	11,350
Vitamin E, I. U. per pound	25

Ingredients

Vitamin A Palmitate (Stability Improved), D Activated Animal Sterol (Source of Vitamin D_3), dl-Alpha Tocopherol Acetate, Sodium Propionate, Corn Distillers Dried Solubles, Corn Distillers Dried Grains, Dried Extracted Ashbya Gossypii Fermentation Meal, Dried Fermentation Solubles From Fungal Amylase Fermentation, Dried Extracted Meal From Streptomyces Olivaceous Fermentation, Calcium Iodate, Manganous Oxide, Ferrous Carbonate, Copper Oxide, Cobalt Carbonate, Zinc Oxide.

1/Specifications determined by the Peter Hand Foundation.

APPENDIX TABLE II. INDIVIDUAL INITIAL AND FINAL WEIGHTS AND AVERAGE DAILY GAIN FOR TRIAL I STEERS.

Lot and ration number												
1			2			3			4			
Steam-rolled barley 2 lb. supplement 6 lb. hay			Steam-rolled barley 2 lb. supplement 2 lb. hay			Steam-rolled barley 2 lb. supplement 0 lb. hay			Dry-rolled barley 2 lb. supplement 2 lb. hay			
Initial wt.	Final wt.	Daily gain	Initial wt.	Final wt.	Daily gain	Initial wt.	Final wt.	Daily gain	Initial wt.	Final wt.	Daily gain	
lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	
810	1055	1.75	915	1340	3.04	790	1160	2.64	915	1200	2.04	
820	1130	2.21	825	1185	2.57	910	1270	2.57	935	1285	2.50	
795	1085	2.07	865	1225	2.57	815	1130	2.25	755	1070	2.25	
890	1240	2.50	785	1085	2.14	895	1205	2.21	905	1260	2.54	
855	1155	2.14	835	1200	2.61	795	1145	2.50	860	1275	2.96	
755	1055	2.14	750	1060	2.21	760	1060	2.14	925	1320	2.82	
885	1200	2.25	870	1185	2.25	710	1005	2.11	700	1000	2.14	
940	1215	1.96	855	1170	2.25	875	1245	2.64	860	1230	2.64	
840	1165	2.32	800	1165	2.61	830	1185	2.54	835	1205	2.64	
885	1190	2.18	950	1330	2.71	935	1230	2.11	815	1165	2.50	
Total:												
8475	11490	21.52	8450	11945	24.96	8315	11635	23.71	8505	12010	25.03	
Average:												
848	1149	2.15	845	1194	2.50	832	1164	2.37	850	1201	2.50	

APPENDIX TABLE III. ANALYSIS OF VARIANCE ON AVERAGE DAILY GAINS OF THE STEERS FED STEAM-ROLLED AND DRY-ROLLED BARLEY WITH THREE LEVELS OF HAY (TRIAL I).

Source of variation	Degrees of freedom	Sums of squares	Mean square	F value
Between treatments	3	0.807	0.269	4.203*
Within treatments	36	2.295	0.064	
Total	39	3.102		

*Significant at the 5% level.

APPENDIX TABLE IV. ANALYSIS OF VARIANCE ON AVERAGE DAILY GAINS OF THE STEERS FED STEAM-ROLLED AND DRY-ROLLED BARLEY WITH THREE LEVELS OF HAY (TRIAL II).

Source of variation	Degrees of freedom	Sums of squares	Mean square	F value
Between treatments	3	0.105	0.035	0.273*
Within treatments	28	3.583	0.128	
Total	31	3.688		

*Not significant.

APPENDIX TABLE V. AVERAGE DAILY FEED CONSUMPTION (POUNDS) PER STEER BY WEIGH PERIOD FOR TRIAL I STEERS.

Lot and ration number	Weigh period				
	Oct. 15- Nov. 11	Nov. 12- Dec. 9	Dec. 10- Jan. 6	Jan. 7- Feb. 3	Feb. 4- March 3
1					
Barley	9.46	17.45	19.80	17.30	16.44
Supplement	1.93	2.00	2.00	2.00	1.96
Hay	9.25	6.00	6.00	6.00	5.79
Salt and mineral	0.16	0.05	0.04	0.02	0.06
Total	20.80	25.50	27.84	25.32	24.25
2					
Barley	9.96	18.56	21.98	19.19	19.20
Supplement	1.93	2.00	2.00	2.00	1.96
Hay	8.34	2.00	2.00	2.00	1.93
Salt and mineral	0.16	0.05	0.04	0.02	0.06
Total	20.39	22.61	26.02	23.21	23.15
3					
Barley	10.45	19.62	23.20	19.21	18.78
Supplement	1.93	2.00	2.00	2.00	1.96
Hay	8.34	0.34	0.00	0.00	0.00
Salt and mineral	0.16	0.05	0.04	0.02	0.06
Total	20.88	22.01	25.24	21.23	20.80
4					
Barley	10.93	20.64	22.82	18.86	18.56
Supplement	1.93	2.00	2.00	2.00	1.96
Hay	7.27	2.00	2.00	2.00	2.00
Salt and mineral	0.16	0.05	0.04	0.02	0.06
Total	20.29	24.69	26.86	22.88	22.58

APPENDIX TABLE VI. POUNDS OF FEED REQUIRED PER HUNDREDWEIGHT GAIN PER STEER BY WEIGH PERIOD FOR TRIAL I STEERS.

Lot and ration number	Weigh period				
	Oct. 15- Nov. 11	Nov. 12- Dec. 9	Dec. 10- Jan. 6	Jan. 7- Feb. 3	Feb. 4- March 3
1					
Barley	375.89	545.92	840.15	888.99	2191.90
Supplement	76.60	62.57	84.85	102.75	261.90
Hay	367.38	187.71	254.54	308.26	771.43
Salt and mineral	6.25	1.68	1.52	0.92	7.14
Total	826.02	797.88	1181.06	1300.92	3232.37
2					
Barley	350.94	538.45	741.57	1143.19	1235.63
Supplement	67.92	58.03	67.47	119.15	126.44
Hay	293.71	58.03	67.47	119.15	124.14
Salt and mineral	5.66	1.55	1.20	1.06	3.45
Total	718.23	656.06	877.71	1382.55	1489.66
3					
Barley	379.87	594.05	948.18	969.19	1365.97
Supplement	70.13	60.54	81.75	100.90	142.86
Hay	303.25	10.27	0.00	0.00	0.00
Salt and mineral	5.85	1.62	1.46	0.90	3.90
Total	759.10	666.48	1031.39	1070.99	1512.73
4					
Barley	402.63	631.69	784.05	831.65	1367.89
Supplement	71.05	61.20	68.71	88.19	144.74
Hay	267.76	61.20	68.71	88.19	147.37
Salt and mineral	5.92	1.64	1.23	0.80	3.95
Total	747.36	755.73	922.70	1008.83	1663.95

APPENDIX TABLE VII. INDIVIDUAL INITIAL AND FINAL WEIGHTS AND AVERAGE DAILY GAIN BY LOTS FOR TRIAL II STEERS.

Lot and ration number	5			6			7			8		
	Steam-rolled barley 2 lb. supplement 5 lb. hay			Dry-rolled barley 2 lb. supplement 2 lb. hay			Steam-rolled barley 2 lb. supplement 2 lb. hay			Steam-rolled barley 2 lb. supplement 0 lb. hay		
	Initial wt.	Final wt.	Daily gain	Initial wt.	Final wt.	Daily gain	Initial wt.	Final wt.	Daily gain	Initial wt.	Final wt.	Daily gain
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
	655	940	1.86	685	1005	2.09	660	1040	2.48	720	1080	2.35
	685	1045	2.35	700	1045	2.25	685	1010	2.12	675	1035	2.35
	810	1180	2.42	775	1125	2.29	705	1030	2.12	750	1125	2.45
	800	1200	2.61	800	1220	2.75	805	1145	2.22	775	1235	3.01
	735	1145	2.68	790	1225	2.84	785	1175	2.55	790	1185	2.58
	780	1150	2.42	825	1300	3.10	705	1080	2.45	705	1020	2.06
	675	1055	2.48	725	1155	2.81	760	1140	2.48	745	1190	2.91
	650	1115	3.04	620	1010	2.55	615	1125	3.33	660	1125	3.04
Total:	5790	8830	19.86	5920	9085	20.68	5720	8745	19.75	5820	8995	20.75
Average:	724	1104	2.48	740	1136	2.59	715	1093	2.47	728	1124	2.59

APPENDIX TABLE VIII. AVERAGE DAILY FEED CONSUMPTION (POUNDS) PER STEER BY WEIGH PERIOD FOR TRIAL II STEERS.

Lot and ration number	Weigh period				
	June 6- July 13	July 14- Aug. 10	Aug. 11- Sept. 7	Sept. 8- Oct. 5	Oct. 6- Nov. 5
5					
Barley	11.45	16.20	16.54	16.52	16.81
Supplement	1.96	2.00	2.00	2.00	2.00
Hay	6.00	5.79	4.32	4.00	4.00
Salt and mineral	0.20	1.34	0.13	0.04	0.12
Total	19.61	25.33	22.99	22.56	22.93
6					
Barley	12.41	17.52	18.45	16.60	18.71
Supplement	1.96	2.00	2.00	2.00	2.00
Hay	3.11	2.00	2.00	2.00	2.00
Salt and mineral	0.20	0.14	0.13	0.04	0.12
Total	17.68	21.66	22.58	20.64	22.83
7					
Barley	13.46	19.21	17.71	16.56	19.50
Supplement	1.96	2.00	2.00	2.00	2.00
Hay	3.13	2.00	2.00	2.00	2.00
Salt and mineral	0.20	0.14	0.13	0.04	0.12
Total	18.75	23.35	21.84	20.60	23.62
8					
Barley	13.42	19.38	20.14	19.00	19.74
Supplement	1.96	2.00	2.00	2.00	2.00
Hay	2.24	0.00	0.00	0.00	0.00
Salt and mineral	0.20	0.14	0.13	0.04	0.12
Total	17.82	21.52	22.27	21.04	21.86

APPENDIX TABLE IX. POUNDS OF FEED REQUIRED PER HUNDREDWEIGHT GAIN PER STEER BY WEIGH PERIOD FOR TRIAL II STEERS.

Lot and ration number	Weigh period				
	June 6- July 13	July 14- Aug. 10	Aug. 11- Sept. 7	Sept. 8- Oct. 5	Oct. 6- Nov. 5
5					
Barley	355.10	437.11	851.49	666.67	1737.50
Supplement	60.82	53.98	102.99	80.72	206.67
Hay	186.12	156.14	222.53	161.44	413.33
Salt and mineral	6.12	3.62	6.90	1.44	12.50
Total	608.16	650.85	1183.91	910.27	2370.00
6					
Barley	397.05	503.08	787.05	646.61	1385.07
Supplement	62.74	57.44	85.33	77.91	148.06
Hay	99.37	57.44	85.33	77.91	148.06
Salt and mineral	6.32	3.84	5.71	1.39	8.96
Total	565.48	621.80	963.42	803.82	1690.15
7					
Barley	421.86	628.32	778.04	742.00	1343.33
Supplement	61.44	65.40	87.84	89.60	137.78
Hay	98.14	65.40	87.84	89.60	137.78
Salt and mineral	6.18	4.38	5.88	1.60	8.34
Total	587.62	763.50	959.60	922.80	1627.23
8					
Barley	471.68	447.42	876.12	842.77	1529.69
Supplement	68.90	46.19	87.00	88.71	155.00
Hay	78.61	0.00	0.00	0.00	0.00
Salt and mineral	7.94	3.10	5.82	1.58	9.37
Total	626.13	496.71	968.94	933.06	1694.06

APPENDIX TABLE X. INDIVIDUAL INITIAL AND FINAL WEIGHTS AND AVERAGE DAILY GAIN BY LOT FOR STEERS IN THE WINTERING TRIAL. 1/

Lot and ration number												
1			2			3			4			
Steam-rolled barley			Steam-rolled barley + molasses			Steam-rolled barley + molasses and celluade			Dry-rolled barley			
Initial wt.	Final wt.	Daily gain	Initial wt.	Final wt.	Daily gain	Initial wt.	Final wt.	Daily gain	Initial wt.	Final wt.	Daily gain	
lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	
Certified steers:												
450	625	2.08	455	595	1.67	455	575	1.43	435	565	1.55	
440	615	2.08	395	550	1.85	475	625	1.79	450	605	1.85	
425	590	1.96	405	565	1.90	410	580	2.02	400	570	2.02	
365	460	1.13	410	545	1.61	435	590	1.85	415	550	1.61	
470	615	1.73	445	575	1.55	400	510	1.31	440	585	1.73	
480	595	1.37	450	615	1.96	445	575	1.55	425	575	1.79	
Other steers:												
465	575	1.31	445	560	1.37	395	505	1.31	360	450	1.07	
450	640	2.26	440	575	1.61	430	605	2.08	455	600	1.73	
490	645	1.85	425	570	1.73	375	515	1.67	395	540	1.73	
475	625	1.79	380	490	1.31	420	560	1.67	455	595	1.67	
500	650	1.79	470	650	2.14	550	690	1.67	415	545	1.15	
505	645	1.67	475	650	2.08	555	720	1.96	495	670	2.08	
Total:												
5515	7280	21.02	5195	6940	20.78	5345	7050	20.31	5140	6850	20.38	
Average:												
460	607	1.75	433	578	1.73	445	588	1.70	428	571	1.70	

1/All steers fed two pounds of a protein supplement and a full feed of mixed grass-alfalfa hay.

APPENDIX TABLE XI. ANALYSIS OF VARIANCE OF AVERAGE DAILY GAIN OF CALVES FED STEAM-ROLLED BARLEY PLUS MOLASSES AND DRY-ROLLED BARLEY (WINTERING TRIAL).

Source of variation	Degrees of freedom	Sums of squares	Mean square	F value
Between treatments	3	0.03	0.01	0.126*
Within treatments	44	3.50	0.08	
Total	47	3.53		

*Not significant.

APPENDIX TABLE XII. ANALYSIS OF VARIANCE OF AVERAGE DAILY GAIN OF CERTIFIED STEERS AND STEERS FROM UNTESTED SIRES (WINTERING TRIAL).

Source of variation	Degrees of freedom	Sums of squares	Mean square	F value
Treatment	3	0.03	0.01	0.117*
Steers	1	0.00	0.00	0.000*
Treatment/steers	3	0.07	0.02	0.268*
Error	40	3.43	0.09	
Total	47	3.53		

*Not significant.

APPENDIX TABLE XIII. ANALYSIS OF VARIANCE OF AVERAGE DAILY GAIN OF CERTIFIED STEERS AND STEERS FROM UNTESTED SIRES (FATTENING TRIAL).

Source of variation	Degrees of freedom	Sums of squares	Mean square	F value
Treatment	3	0.24	0.08	1.30*
Steers	1	0.78	0.78	13.00**
Treatment/steers	3	1.21	0.40	6.67**
Error	38	2.30	0.06	
Total	45	4.53		

*Not significant.
**Significant at the 1% level.

APPENDIX TABLE XIV. INDIVIDUAL INITIAL AND FINAL WEIGHTS AND WEIGHT GAIN OF STEERS FROM DIFFERENT SOURCES (WINTERING TRIAL).

Source of cattle	No. of steers	Tatoo no.	Wintering trial (84 days) December 30, 1960 to March 24, 1961			
			Initial wt.	Final wt.	Gain, total	Avg. daily gain
			lb.	lb.	lb.	lb.
IPR herd, sire number						
Group 1	4	0089	450	625	175	2.08
		0041	455	595	140	1.67
		0130	455	575	120	1.43
		0120	435	565	130	1.55
# 818	4	0210	440	615	175	2.08
		0215	395	550	155	2.85
		0150	475	625	150	1.79
		0177	450	605	155	1.85
# 690	4	0203	425	590	165	1.96
		0184	405	565	160	1.90
		0153	410	580	170	2.02
		0216	400	570	170	2.02
# 805	4	0224	365	460	90	1.07
		0221	410	545	135	1.61
		0185	435	590	155	1.85
		0198	415	550	135	1.61
# 6	4	0195	470	615	145	1.73
		0231	445	575	130	1.55
		0191	400	510	110	1.31
		0199	440	585	145	1.73
Total	20		8575	11490	2910	34.66
Average	4		429	574	146	1.73
Group 1 (Warren cows)						
	4	0044	480	595	115	1.37
		0142	450	615	165	1.96
		0077	445	575	130	1.55
		0111	425	575	150	1.79
Total	4		1800	2360	560	6.67
Average			450	590	140	1.67

APPENDIX TABLE XIV. CON'T.

Source of cattle	No. of steers	Ear tag no.	Wintering trial (84 days) December 30, 1960 to March 24, 1961			
			Initial wt.	Final wt.	Gain, total	Avg. daily gain
			lb.	lb.	lb.	lb.
Steers from untested sires						
Manhattan	4	319	465	575	110	1.31
		312	445	560	115	1.37
		305	395	505	110	1.31
		303	360	450	90	1.07
Livingston	16	318	450	640	190	2.26
		310	440	575	135	1.61
		320	430	605	175	2.08
		313	455	600	145	1.73
		309	490	645	155	1.85
		311	425	570	145	1.73
		317	375	515	140	1.67
		286	395	540	145	1.73
		307	475	625	150	1.79
		301	380	490	110	1.31
		315	420	560	140	1.67
		302	455	595	140	1.67
		314	500	650	150	1.79
		306	470	650	180	2.14
		308	550	690	140	1.67
		316	415	545	130	1.55
Total	20		8790	11585	2795	33.31
Average			440	579	139	1.67
Red Bluff	4	44	505	645	140	1.67
		67	475	650	175	2.08
		13	555	720	165	1.96
		7	495	670	175	2.08
Total			2030	2685	655	7.79
Average			508	671	163	1.95

APPENDIX TABLE XV. AVERAGE DAILY FEED CONSUMPTION PER STEER BY WEIGH PERIOD (WINTERING TRIAL).

Lot and ration number	Weigh periods		
	Dec. 30 to Jan. 26	Jan. 27 to Feb. 23	Feb. 24 to March 24
	lb.	lb.	lb.
1, 2, 3, & 4			
Barley	2.32	3.34	5.29
Supplement	1.70	2.00	2.00
Hay	8.14	8.00	8.00
Mineral	0.09	0.01	0.21
Total	12.25	13.35	15.50

APPENDIX TABLE XVI. POUNDS OF FEED REQUIRED PER HUNDREDWEIGHT GAIN PER STEER BY WEIGH PERIOD (WINTERING TRIAL).

Lot and ration number	Weigh periods		
	Dec. 30-Jan. 26	Jan. 27-Feb. 23	Feb. 24-March 24
1			
Barley	127.87	252.13	250.14
Supplement	93.77	151.01	94.65
Hay	448.52	604.04	378.59
Mineral	4.92	1.12	9.86
Total	675.08	1008.30	733.24
2			
Barley	128.93	257.93	251.91
Supplement	94.55	154.48	95.32
Hay	452.23	617.93	381.28
Mineral	4.96	1.15	9.93
Total	680.67	1031.49	738.44
3			
Barley	138.05	233.75	269.09
Supplement	101.24	140.00	101.82
Hay	484.25	560.00	407.27
Mineral	5.31	1.04	10.61
Total	728.85	934.79	788.79
4			
Barley	114.71	222.18	338.29
Supplement	84.12	133.07	128.00
Hay	402.35	532.28	512.00
Mineral	4.41	1.00	13.33
Total	605.59	888.53	991.62

APPENDIX TABLE XVII. INDIVIDUAL INITIAL AND FINAL WEIGHTS AND AVERAGE DAILY GAIN BY LOT FOR STEERS ON FATTENING TRIAL. 1/

Lot and ration number												
1			2			3			4			
Steam-rolled barley			Steam-rolled barley + molasses			Steam-rolled barley + molasses + celluade			Dry-rolled barley			
Initial wt.	Final wt.	Daily gain	Initial wt.	Final wt.	Daily gain	Initial wt.	Final wt.	Daily gain	Initial wt.	Final wt.	Daily gain	
lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	
Certified steers:												
625	1075	2.51	595	1010	2.32	575	1085	2.85	565	1010	2.49	
615	1125	2.85	bloated			625	1115	2.74	605	1000	2.21	
590	1065	2.65	565	1080	2.88	580	1060	2.68	570	1090	2.91	
460	910	2.51	545	1005	2.57	590	1020	2.40	550	995	2.49	
615	1140	2.93	575	1025	2.51	510	970	2.57	585	1055	2.63	
595	1030	2.43	615	1110	2.77	575	930	1.98	575	1055	2.68	
Other steers:												
575	1005	2.40	560	940	2.12	505	935	2.40	450	780	1.84	
640	1055	2.32	575	925	1.96	605	1015	2.29	600	950	1.96	
645	1105	2.57	570	965	2.21	515	955	2.46	died 9/13/61			
625	1095	2.63	490	860	2.07	560	1010	2.51	595	950	1.98	
650	1040	2.18	650	1055	2.26	690	995	1.70	545	980	2.43	
645	1150	2.82	650	1185	2.99	720	1255	2.99	670	1110	2.46	
Total:												
7280	12795	30.80	6390	11160	26.66	7050	12345	29.57	6310	10975	26.08	
Average:												
607	1066	2.56	581	1014	2.42	588	1029	2.46	574	998	2.37	

1/All steers fed one pound protein supplement and two pounds mixed grass-alfalfa hay.

APPENDIX TABLE XVIII. A COMPARISON OF AVERAGE DAILY GAIN (POUNDS) BY WEIGH PERIOD OF CERTIFIED STEERS AND STEERS FROM UNTESTED SIRES (FATTENING TRIAL).

Lot and ration number		Date of weigh period						
		3/24-4/21	4/22-5/19	5/20-6/16	6/17-7/13	7/14-8/10	8/11-9/5	9/6-9/19 1/
1.	A. 2/	2.24	3.86	3.68	2.52	2.82	2.96	-1.38
	B. 3/	2.03	3.61	3.79	1.96	2.39	2.85	-2.08
2.	A.	2.63	3.53	3.57	2.22	2.68	2.64	-1.44
	B.	1.93	2.82	3.11	1.89	2.64	1.92	-1.31
3.	A.	2.76	3.39	3.86	2.30	2.86	1.92	-0.08
	B.	2.00	2.93	3.36	2.04	2.46	1.88	0.00
4.	A.	2.55	3.11	3.39	2.63	2.04	2.46	0.54
	B.	2.63	2.05	3.39	1.25	1.70	1.88	0.67

1/Weight obtained after a 16-hour overnight shrink without feed or water.
2/Five certified steers.
3/Five steers from untested sires.

APPENDIX TABLE XIX. AVERAGE DAILY FEED CONSUMPTION (POUNDS) PER STEER BY WEIGH PERIOD FOR STEERS ON FATTENING TRIAL.

Lot and ration number	Date of weigh period						
	3/24-4/21	4/22-5/19	5/20-6/16	6/17-7/13	7/14-8/7	8/8-9/5	9/6-9/19
1							
Barley	9.52	16.55	19.95	17.26	19.39	19.26	16.87
Supplement	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hay	6.45	2.82	2.00	2.00	2.00	2.00	2.00
Salt and mineral	0.22	0.09	0.15	0.06	0.00	0.06	0.00
Total	17.19	20.46	23.10	20.32	22.39	22.32	19.87
2							
Barley	9.52	16.04	17.59	17.62	18.58	18.58	16.15
Supplement	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hay	6.45	2.82	2.00	2.00	2.00	2.00	2.00
Salt and mineral	0.22	0.09	0.12	0.06	0.00	0.07	0.00
Total	17.19	19.95	20.71	20.68	21.58	21.65	19.15
3							
Barley	9.52	16.17	19.63	17.21	18.61	17.46	15.85
Supplement	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hay	6.45	2.82	2.00	2.00	2.00	2.00	2.00
Salt and mineral	0.18	0.09	0.09	0.09	0.00	0.06	0.00
Total	17.15	20.08	22.72	20.30	21.61	20.52	18.85
4							
Barley	9.52	15.32	17.95	16.01	16.93	15.54	14.89
Supplement	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hay	6.45	2.82	2.00	2.00	2.00	2.00	2.08
Salt and mineral	0.18	0.09	0.12	0.02	0.00	0.06	0.00
Total	17.15	19.23	21.07	19.03	19.93	18.60	18.01

APPENDIX TABLE XX. POUNDS OF FEED REQUIRED PER HUNDREDWEIGHT GAIN PER STEER BY WEIGH PERIOD (FATTENING TRIAL).

Lot and ration number	Date of weigh period						
	3/24-4/21	4/22-5/19	5/20-6/16	6/17-7/13	7/14-8/7	8/8-9/5	9/6-9/19
1							
Barley	435.79	443.19	542.83	750.47	757.67	667.78	1/
Supplement	45.79	26.77	27.21	43.49	39.07	34.67	
Hay	295.26	75.54	54.41	86.98	78.14	69.33	
Salt and mineral	10.39	2.39	4.05	2.68	0.00	2.22	
Total	787.23	547.89	628.50	883.65	874.88	774.00	
2							
Barley	396.65	510.71	522.87	865.12	673.41	764.60	
Supplement	41.68	31.85	29.72	49.09	36.24	41.15	
Hay	268.74	89.86	59.44	98.18	72.47	82.30	
Salt and mineral	9.11	2.85	3.70	3.30	0.00	2.88	
Total	716.18	635.27	615.73	1015.69	782.12	890.93	
3							
Barley	394.29	500.83	542.88	802.45	748.74	871.68	
Supplement	41.43	30.97	27.65	46.62	40.24	49.92	
Hay	267.14	87.37	55.31	93.24	80.48	99.84	
Salt and mineral	7.62	2.76	2.47	4.32	0.00	3.20	
Total	710.48	621.93	628.31	946.63	869.46	1024.64	
4							
Barley	365.97	536.04	540.90	730.42	917.42	673.33	3191.42
Supplement	38.45	35.00	30.13	45.63	54.19	43.33	222.86
Hay	247.96	98.75	60.27	91.27	108.39	86.67	445.71
Salt and mineral	7.07	3.12	3.58	2.82	0.00	2.78	0.00
Total	659.45	672.91	634.88	870.14	1080.00	806.11	3859.99

1/Blank spaces denote a net loss of weight during the period.

APPENDIX TABLE XXI. AVERAGE WEIGHT GAIN OF CERTIFIED STEERS AND STEERS FROM UNTESTED SIRES (FATTENING TRIAL).

Source of cattle	No. of steers	Tatoo no.	Fattening trial (179 days) March 24, 1961 to September 19, 1961			
			Initial wt. lb.	Final wt. lb.	Total gain lb.	Avg. daily gain lb.
IPR herd, sire number						
Group 1	4	0089	625	1075	450	2.51
		0041	595	1010	415	2.32
		0130	575	1085	510	2.85
		0120	565	1010	445	2.49
# 818	3	0210	615	1125	510	2.85
		0215	removed 5/28/61 due to bloat			
		0150	625	1115	490	2.74
		0177	605	1000	395	2.21
# 690	4	0203	590	1065	475	2.65
		0184	565	1080	515	2.88
		0153	580	1060	480	2.68
		0216	570	1090	520	2.91
# 805	4	0224	460	910	450	2.51
		0221	545	1005	460	2.57
		0185	590	1020	430	2.40
		0198	550	995	445	2.49
# 6	4	0195	615	1140	525	2.93
		0231	575	1025	450	2.51
		0191	510	970	460	2.57
		0199	585	1055	470	2.63
Total	19		10940	19835	8895	49.70
Average			576	1044	468	2.62
Group 1 (Warren cows)						
	4	0044	595	1030	435	2.43
		0142	615	1110	495	2.77
		0077	575	930	355	1.98
		0111	575	1055	480	2.68
Total	4		2360	4125	1765	9.86
Aveage			590	1031	441	2.46

APPENDIX TABLE XXI. CON'T.

Source of cattle	No. of steers	Ear tag no.	Fattening trial (179 days) March 24, 1961 to September 19, 1961			
			Initial wt. lb.	Final wt. lb.	Total gain lb.	Avg. daily gain lb.
Steers from untested sires						
Manhattan	4	319	575	1005	430	2.40
		312	560	940	380	2.12
		305	505	935	430	2.40
		303	450	780	330	1.84
Livingston	15	318	640	1055	415	2.32
		310	575	925	350	1.96
		320	605	1015	410	2.29
		313	600	950	350	1.96
		309	645	1105	460	2.57
		311	570	965	395	2.21
		317	515	955	440	2.46
		286	died 9/13/61			
		307	625	1095	470	2.63
		301	490	860	370	2.07
		315	560	1010	450	2.51
		302	595	950	355	1.98
		314	650	1040	390	2.18
		306	650	1055	405	2.26
		308	690	995	305	1.70
		316	545	980	435	2.43
Total	19		11045	18615	7570	42.29
Average			581	980	399	2.23
Red Bluff	4	44	645	1150	505	2.82
		67	650	1185	535	2.99
		13	720	1255	535	2.99
		7	670	1110	440	2.46
Total	4		2685	4700	2015	11.26
Aveage			671	1175	504	2.82

APPENDIX TABLE XXII. AVERAGE WEIGHT GAIN OF CERTIFIED STEERS AND STEERS FROM UNTESTED SIRES DURING THE WINTERING AND FATTENING TRIALS.

Source of cattle	No. of steers	Tatoo no.	Wintering and fattening trials (263 days) Gain	Avg. daily gain
			lb.	lb.
IPR herd, sire number				
Group 1	4	0089	625	2.38
		0041	555	2.11
		0130	630	2.40
		0120	575	2.19
# 818	3	0210	685	2.60
		0215	000	0.00
		0150	640	2.43
		0177	550	2.09
# 690	4	0203	640	2.43
		0184	675	2.57
		0153	650	2.47
		0216	690	2.62
# 805	4	0224	540	2.05
		0221	595	2.26
		0185	585	2.22
		0198	580	2.21
# 6	4	0195	670	2.55
		0231	580	2.21
		0191	570	2.17
		0199	615	2.34
Total	19		11650	44.30
Average			613	2.33
Group 1 (Warren cows)				
	4	0044	550	2.09
		0142	660	2.51
		0077	485	1.84
		0111	630	2.40
Total			2325	8.84
Average			581	2.21

APPENDIX TABLE XXII. CON'T.

Source of cattle	No. of steers	Ear tag no.	Wintering and fattening trials (263 days) Gain lb.	Avg. daily gain lb.
Steers from untested sires				
Manhattan	4	319	540	2.05
		312	495	1.88
		305	540	2.05
		303	420	1.60
Livingston	15	318	605	2.30
		310	485	1.84
		320	585	2.22
		313	495	1.88
		309	615	2.34
		311	540	2.05
		317	580	2.21
		286	000	0.00
		307	620	2.36
		301	480	1.83
		315	590	2.24
		302	495	1.88
		314	540	2.05
		306	585	2.22
		308	445	1.69
		316	565	2.15
Total	19		10220	38.84
Average			538	2.04
Red Bluff	4	44	645	2.45
		67	710	2.70
		13	700	2.66
		7	615	2.34
Total	4		2670	10.15
Average			668	2.54

LITERATURE CITED

Agarwala, O. P. 1958. Rumen digestion. The Indian J. Vet. Sci. and An. Hus. 28:171.

Annison, E. F. and D. Lewis. 1959. Metabolism in the Rumen. (1st ed.) John Wiley and Sons Inc., New York.

Barton-Wright, E. C. 1958. The problem of protein haze in bottled beer. Biol. Abstr. 32, No. 29989.

Beardsley, D. W., W. C. McCormick, and B. L. Southwell. 1959. Steer performance on and rumen effects of different concentrate:roughage ratios in pelleted and unpelleted mixed fattening rations. J. Animal Sci. 18:1507. (Abstr.)

Beeson, W. M., T. W. Perry, M. T. Mohler, and W. H. Smith. 1961. Levels of supplemental vitamin A for fattening beef cattle. J. Animal Sci. 20:925. (Abstr.)

Bentley, Orville G., M. Moinuddin, T. V. Hershberger, E. W. Klosterman, and A. L. Moxon. 1954. The effect of trace minerals on growth performance and vitamin B_{12} synthesis of steers. J. Animal Sci. 13:789.

Blaizot, J. and P. Raynaud. 1957. Presence of free amino acids in the rumen of cattle. Nutr. Abstr. and Rev. 27:765.

Brownlee, A. and J. Elliot. 1961. The influence of diet on the presence of an iron-containing pigment in the keratinised layer of the epithelium of the rumen, reticulum, and omasum of cattle. Vet. Record 73:384.

Davis, R. F., N. S. Woodhouse, Mark Keeney, and G. H. Beck. 1957. The effect of various levels of dietary protein upon the volatile fatty acids in the rumen of the dairy cow. J. Dairy Sci. 40:75.

Dowe, Thomas W., V. H. Arthaud, and John Matsushima. 1955. Ratio of concentrates to alfalfa hay in fattening rations for beef cattle. Univ. of Neb. Exp. Sta. Bull. 431.

Dowe, Thomas W., J. Matsushima, and V. Arthaud. 1955. The effects of the corn-alfalfa hay ratio on the digestibility of the different nutrients by cattle. J. Animal Sci. 14:340.

Duncan, David B. 1955. Multiple range and multiple F tests. Biometrics 11:1.

Emery, R. S., C. K. Smith, and C. F. Huffman. 1956. The amounts of short chain acids formed during rumen fermentation. J. Animal Sci. 15:854.

Encyclopedia Americana. 1961. American Corporation, New York. Vol. 3, p. 257.

Hale, E. B., Farris Hubbert, Jr., R. E. Taylor, T. H. Anderson, and Bruce Taylor. 1961. The effect of feeding high levels of vitamin A to beef cattle. Arizona Cattle Feeders Day, p. 7.

Hale, E. B., C. W. Duncan, and C. F. Huffman. 1947. Rumen digestion studies. J. Nutr. 34:747.

Haynes, E. H., R. F. Davis, R. G. Warner, and J. K. Loosli. 1955. The digestion coefficients of feeds containing various ratios of hay to grain by fistulated steers and milking cows. J. Animal Sci. 14:1206. (Abstr.)

Hibbs, J. W., H. R. Conrad, W. D. Pounden, and Norma Frank. 1956. A high roughage system for raising calves based on early development of rumen function. VI. Influence of hay to grain ratio on calf performance, rumen development, and certain blood changes. J. Dairy Sci. 39:171.

Hollis, Leroy, Charles F. Chappel, Robert MacVicar, and C. K. Whitehair. 1954. Effect of ration on vitamin synthesis in rumen. J. Animal Sci. 13:732.

Hubbert, Farris, Jr., W. H. Hale, Wm. J. Carey, Jr., E. B. Stanley, and Bruce Taylor. 1961. Vitamin A for feedlot cattle. Arizona Cattle Feeders Day, p. 10.

Hubbert, Farris, Jr., Bruce Taylor, C. R. Roubicek, R. E. Taylor, E. B. Stanley, and E. H. Hussman. 1960. Protein level and phosphorus: protein ratio in fattening rations. Arizona Cattle Feeders Day, p. 27.

Hubbert, Farris, Jr., Glen Hall, R. K. Anderson, Edmund Cheng, and Wise Burroughs. 1955. Mineral requirements for cellulolytic rumen microorganisms. J. Animal Sci. 14:1209. (Abstr.)

Jensen, Rue, W. E. Connell, and A. W. Deem. 1954. Rumenitis and its relation to rate of change of ration and the proportion of concentrate in the ration of cattle. Am. J. Vet. Res. 15:425.

Keith, T. B., T. Donald Bell, and J. J. Dahmen. 1961. Most economical levels of concentrate to roughage. Steer Feeding Research, Idaho Agr. Exp. Sta. Bull. 343, p. 10.

Keith, T. B., R. F. Johnson, and W. P. Lehrer, Jr. 1954. Optimum ratio of concentrate to alfalfa hay for steers as affected by protein level and method of feeding. Idaho Agr. Exp. Sta. Research Bull. 26.

Klosterman, Earle W., Orville G. Bentley, A. L. Moxon, and L. E. Kunkle. 1956. Relationships between level of protein, molasses, trace minerals and quality of hay in rations for fattening cattle. J. Animal Sci. 15:456.

Knapp, Bradford, Jr., and Arne W. Nordskog. 1946. Heritability of growth and efficiency in beef cattle. J. Animal Sci. 5:62.

Knapp, Bradford, Jr., and Arne W. Nordskog. 1946. Heritability of live animal scores, grades, and certain carcass characteristics in beef cattle. J. Animal Sci. 5:194.

Lewis, D. 1961. Digestive Physiology and Nutrition of the Ruminant. Butterworth and Col Ltd., London.

Ljungdahl, Lars and Evald Sandegren. 1956. Amino acids in barley, malt, wort, and beer. Biol. Abstr. 30, No. 17659.

MacLeod, Robert A. and J. F. Murray. 1956. Some factors affecting cellulose digestion by rumen microorganisms in vitro. J. Nutr. 60:245.

Masson, M. J. and A. T. Phillipson. 1951. The absorption of acetate, propionate and butyrate from the rumen of sheep. J. Physiology 113:189.

Maynard, Leonard A. and John K. Loosli. 1956. Animal Nutrition. (4th ed.) McGraw-Hill Book Co. Inc., New York.

Mead, S. W. and Harold Goss. 1935. Ruminant digestion without roughage. J. Dairy Sci. 18:163.

Mitchel, H. H. 1947. The mineral requirements for farm animals. J. Animal Sci. 6:365.

Morrison, Frank B. 1959. Feeds and Feeding. (22nd ed.) The Morrison Publishing Co., Clinton, Iowa.

Nutr. Revs. 1960. Nutritional significance of the rumen. 18:208.

Nutr. Revs. 1958. Rumen parakeratosis from pelleted feeds. 16:299.

Nutr. Revs. 1958. Improving the nutritional value of barley. 16:108.

Nutr. Revs. 1956. Vitamin synthesis in ruminants. 14:209.

Orcutt, E. P. 1957. What is an IPR bull. Mont. State Coll. Ext. Service Circular 264.

Oyaert, W. and J. H. Bouckeart. 1961. Quantitative aspects of food digestion in the rumen. Nutr. Abstr. and Rev. 31:857.

Pahnish, O. F., E. B. Stanley, and C. G. Schillingburg, Jr. 1956. Effects of roughage levels on fattening cattle in Arizona. Univ. of Arizona Agr. Sta. Bull. 272.

Patterson, R. E., T. C. Cartwright, J. H. Jones, and J. J. Bayles. 1955. Performance testing of beef breeding stock. J. Animal Sci. 14:1034.

Pennington, R. J. 1952. The metabolism of short-chain fatty acids in the sheep. I. Fatty acid utilization and ketone body production by rumen epithelium and other tissues. Biochem. J. 51:251.

Phillipson, A. T. 1960. The nutrition of the ruminant. Vet. Record 72:613.

Pope, L. S., R. D. Humphrey, L. E. Walters, and V. G. Heller. 1956. Fattening steers and heifers on rations containing different levels of concentrate. 1955-56 Progress Report. Oklahoma A. & M. Exp. Sta. MP-45, p. 100.

Richardson, D., E. F. Smith, and R. F. Cox. 1953. Ratio of roughage to grain for fattening steer calves. Kansas Agr. Exp. Sta. Circular 297, p. 50.

Rogers, Terence A. 1958. The metabolism of ruminants. Scientific American 198:34.

Senti, Frederic R. and W. Dayton Maclay. 1961. Age-old uses of seeds and some new ones. Seeds, The Yearbook of Agriculture, 1961. The U. S. Dept. of Agr., Washington, D. C., p. 27.

Stewart, W. E., Daryl G. Stewart, and L. H. Schultz. 1958. Rates of volatile fatty acid production in the bovine rumen. J. Animal Sci. 17:723.

Taylor, Bruce, Farris Hubbert, Jr., C. B. Roubicek, R. E. Taylor, E. B. Stanley, and E. H. Hussman. 1960. Steam-rolled vs. dry-rolled milo and barley. Arizona Cattle Feeders Day, p. 24.

Thaysen, A. C. 1951. The nutritional role of the microflora in the alimentary tract. The microbiological aspect of rumen digestion. Vet. Bull. 21:697. (Abstr.)

Urban, Kenneth, L. S. Pope, and Dwight Stephens. 1959. Comparison of 2 methods of preparing barley for fattening steer calves. Oklahoma State Univ. Agr. Exp. Sta. Misc. Pub. MP-55, p. 35.

Vidacs, G. and G. M. Ward. 1960. Parakeratosis condition of rumen epithelium produced by an all-concentrate ration. J. Dairy Sci. 43:875.

Ward, G. M. 1962. Ruminal parakeratosis and other feed induced lesions. Feedstuffs 34:26.

Watson, C. J., J. W. Kennedy, W. M. Davidson, C. H. Robinson, and G. W. Muir. 1950. Digestibility studies with ruminants. X. Relative associative effects of the roughages, timothy and alfalfa with barley. Vet. Bull. 20:756. (Abstr.)

Wise, Milton B., T. N. Blumer, G. Matrone, and E. R. Barrick. 1961. Investigations on the feeding of all-concentrate rations to beef cattle. J. Animal Sci. 20:561.