AN ABSTRACT OF THE THESIS OF

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Title: ALTERNATE METHODS OF FATTENING STEERS IN EASTERN OREGON

Abstract approved Redacted for Privacy

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Studies were conducted at the Squaw Butte Experiment Station during two consecutive years to : (1) compare various internal indicators and chromic oxide to estimate forage intake and fecal production, (2) compare methods of producing slaughter weight steers using maximum quantities of forage and minimum quantities of grain. Actual fecal output of six 208 kg steers was correlated to chromic oxide (Cr_2O_3) estimates of fecal output for collection times of 0700, 1200, 1700 and composite with respective correlation coefficients of .63, .59, .80 and .79. The average recovery of Cr_2O_3 was $94.05 \pm 3.91\%$. Estimates of forage intake using lignin(L), crude fiber (CF), nitrogen (N) and indigestible dry matter were correlated to actual forage consumption with respective coefficients (r) of .92, .93, .96 and .89. No significant differences were found between collection times of 0700, 1200, 1700 and the composite sample for L, CF or N estimates of forage consumption. Estimates of forage consumption were most accurately predicted by the L and CF methods.

Three trials conducted using a total of 129 Hereford or Hereford X Angus steers evaluated the performance of steers on irrigated pasture and

crested wheatgrass range during the growing phase (trials 1 and 2). The steers were allotted to various finishing regimes from the growing study. These included finishing on irrigated pasture, on range and in the feedlot using two 40% roughage based rations for trial 1 and four 40% roughage based rations in trial 2. Trial 3 was conducted using fall born steers which were either immediately sent to the feedlot and fed two 38% straw based rations, put on irrigated pasture prior to going to the feedlot or grazed on irrigated pasture, wintered on a 100% forage diet of 2/3 alfalfa and 1/3 grass hay and then finished on crested wheatgrass range the following spring. Faster ($P<.05$) gains were made on crested wheatgrass range than on either alfalfa-fescue or clover-fescue irrigated pastures. Steers finished on irrigated pasture and range made greater daily gains than steers receiving the 40% roughage rations in the feedlot of trial 1. The feedlot steers gained faster in trial 2 with the range steers gaining the least ($P<.05$). In both trials the feedlot groups had greater ($P<.05$) 24 hour carcass weights due to a longer feeding period. Carcass grades were lowest for the alfalfa-fescue steers. Overall desirability of the beef was greatest for the feedlot steers.

Daily gains were lowest ($P<.05$) for the fall born steers finished on crested wheatgrass as compared to steers finished on 40% roughage rations. Carcass weight, grade and marbling scores were not significantly different between treatments. Less than 86 kg of barley was used to produce slaughter weight steers from the crested wheatgrass range treatment.

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ALTERNATE METHODS OF FATTENING STEERS IN EASTERN OREGON

INTRODUCTION

As the population of the world continues to increase, human competition for grain now being fed to livestock will decrease the quantities of grain available for finishing cattle. In order to continue to provide adequate quantities of animal protein the re-evaluation of finishing cattle with maximum quantities of forage and minimum quantities of grain is needed. The use of poor quality roughages such as straw in the finishing ration is one method by which to reduce grain consumption. Another is growing and finishing cattle utilizing improved rangelands, such as crested wheatgrass or irrigated pastures. The studies reported in this thesis were designed to evaluate the productive efficiencies of various methods of fattening steers in eastern Oregon.

The thesis reported here utilizes the format of a journal article in an attempt to compile the data which was collected in the most concise and useful way. A detailed literature review is presented on subject matter relative to these studies. The subsequent chapters are written as journal articles for the Journal of Animal Science.

The first journal article compares various indicators for estimation of forage intake and fecal production. The second compares methods of producing slaughter weight steers using maximum quantities of forage. The next chapter is an economic analysis of the finishing alternatives and is not written as a journal article. Detailed summarization of individual animal data and comments on indicator estimates of forage consumption under grazing conditions are available in the appendices.

LITERATURE REVIEW

Indicator Techniques for Estimating Fecal Production and Forage Intake

The majority of work with indicators has been in the area of determining digestibility of various feeds. The indicator method offers several advantages over the conventional digestion trial which requires the complete record of nutrient consumption and total collection of feces. The conventional method is generally accepted as the most accurate technique. It involves special metabolism stalls for collection of feces or fecal collection bags and removes the animal from his natural environment. This method involves unlimited hours of labor by technicians and other workers.

An alternative to the total collection procedure is the use of inert reference substances or "indicator" substances which are naturally occurring or can be added to the feedstuffs being studied. The digestibility coefficient of a nutrient can then be found by determining the ratio of the concentration of the indicator in the dry matter of the feed to that which appeared in the feces. If the fecal production of an animal is known, the preceding ratio of concentrations can be used to determine intake by the following formula:

$$\text{Forage Intake}(g)=\frac{\text{Fecal Production}(g) \text{ X Internal Indicator in feces}(g/g)}{\text{Internal Indicator in forage}(g/g)}$$

Internal indicators are substances occurring naturally within the forage. These include lignin, crude fiber, chromogens, silica, nitrogen and cell wall constituents.

Before forage intake can be determined, fecal production must be known. Basically, two procedures are used for determining fecal production. The first approach has been direct and has generally involved fixing harness and bag to the animal, permitting total fecal collection. This method is open to the criticism that the harness may interfere with grazing habits and is very laborious. The harness attachments tend to irritate the animal's skin with time and it is also likely to catch in gates and fences (Pryor, 1966).

The second approach has been to use indigestible external "tracers". This approach was first credited to Edin of Sweden in 1918 by Kotb and Luckey (1972). External markers or indicators are indigestible substances not naturally occurring in the forage. These substances include chromic oxide (Cr_2O_3), iron oxide, mineral salts, metal or plastic particles and dyes. Also, the use of isotopes as external markers has been studied (Young et al., 1976). By knowing the amount of marker fed to the animal and the concentration in the feces an estimate of fecal production can be made by the following formula:

$$\text{Fecal Production}(g) = \frac{\text{Marker}(g)}{\text{Marker Concentration in feces}(g/g)}$$

A marker should possess the following properties (Raymond and Minson, 1955). It should be (1) quantitatively recovered in the feces, (2) nontoxic, (3) inexpensive, (4) readily analyzed by physical or chemical methods, (5) present only in small amounts in the original diet. Another property added by Pryor (1960) is (6) that variation in the concentration of marker throughout the day should be small and/or vary in a predictable and uniform way.

The studies reported in this thesis deal with the use of chromic oxide to predict fecal output and lignin, crude fiber, nitrogen and indigestible dry matter for estimating forage intake. Thus, the indicator techniques which are reviewed deal with these four markers. Excellent reviews covering all nutritional markers are available (Streeter, 1969; Kotb and Luckey, 1972; Theurer, 1970).

Chromic Oxide (Cr_2O_3). Pryor (1966) has a complete review of work with Cr_2O_3 as an external indicator for predicting fecal production and digestibility. Work reported by Hardison et al. (1956) indicated that Edin (1918) was the first to use Cr_2O_3 as an indicator by feeding a combination of Cr_2O_3 and macaroni to dairy cattle. Edin observed a diurnal pattern of fecal chromic oxide concentration occurring with the same number of peaks as the number of doses of the tracer given. Brisson et al. (1957) later showed that frequent daily dosing gives more uniform content in the feces.

From the very early reports it was evident that a major problem with Cr_2O_3 was the diurnal variation and acquiring samples which represent the actual fecal concentrations of the marker. Barnicoat (1945) in an experiment with lambs, pigs and calves encountered problems with incomplete recovery of Cr_2O_3. He suggested that Cr_2O_3 recovery was offset by the following: (1) losses through error, (2) losses of Cr_2O_3 in food, (3) loss by solution and absorption in the digestive tract, (4) stratification of Cr_2O_3 in the digestive tract, (5) retention in the digestive tract and (6) lag between feeding and excretion of Cr_2O_3.

In an effort to reduce the diurnal variation of Cr_2O_3, researchers have employed various methods of administration. Edin was reported to have administered Cr_2O_3 mixed with macaroni to dairy cows in 1918 (Hardison et al., 1956). Barnicoat (1945), Coup (1950), Hardison and Reid (1953), Pigden and Brisson (1956) and a number of other workers used Cr_2O_3 powder in gelatin capsules. Raymond and Minson (1955) administered Cr_2O_3 in drench form in a suspension of bentonite and water.

Chromic oxide has been mixed with flour, gelatin and collodion without improving recovery (Miller et al., 1957). Radioactive $^{51}Cr_2O_3$ was used by Kane et al. (1959). This technique gave recoveries similar to Cr_2O_3 powder, but due to the disposal problems of radioactive waste and the necessity of radioisotope facilities offers no improvement.

Pigden and Brisson (1957) prepared and used a "sustained release pellet" prepared from a mixture of 25 parts Cr_2O_3, 25 parts commercial dental plaster and 31 parts water by weight. These and other workers have found some improvement in diurnal variation, but recovery of Cr_2O_3 was more variable (Troelsen, 1961; Border, 1962; Eng, 1962; Troelsen, 1965a; Fisher et al., 1965).

Corbett et al. (1958) compared chromium sesquioxide (Cr_2O_3) concentrations of duodenal contents of sheep given a single dose as powder (1) in a gelatin, (2) in plaster of Paris and (3) in paper made by heating Cr_2O_3 in a 3% stock of fully bleached sulphite wood pulp to which was added aluminum sulphate at 1% of dry matter. This product is referred to as Cr_2O_3-paper. The Cr_2O_3-paper was given in a gelatin capsule.

Corbett and Greenhalgh (1960) reported that shredding the paper resulted in further improvement by reducing fecal Cr_2O_3 variation in confined sheep dosed once daily. Border (1962), working with sheep, obtained average fecal recoveries of Cr_2O_3 prepared by Corbett's paper method. Langlands et al. (1963b) reported more stable errors of estimates of fecal output when Cr_2O_3 was administered in paper instead of capsules. Streeter and Clanton (1964), using Cr_2O_3-paper, obtained Cr_2O_3 recoveries of 145.2% for hay and 161.9% for grass clippings when fed to steers.

Troelsen (1963) stated that administration of Cr_2O_3-paper was inconvenienced by bulkiness of the paper. The problem was overcome by compressing the shredded paper in a die, resulting in a pellet of specific gravity of 1.5. Later, on the basis of hourly grab samples from two sheep Troelsen (1965b) found Cr_2O_3 daily recovery to range between 84 and 125% of the Cr_2O_3 administered.

The evidence is very suggestive that the Cr_2O_3-paper method of Corbett and co-workers is a significant improvement on Cr_2O_3 powder in reducing variability in excretion in sheep. However, further evaluation is needed in cattle. The Cr_2O_3-paper method has some obvious drawbacks. Administration of the capsules is a laborious task and will reduce the number of animals receiving Cr_2O_3. The time spent dosing will also reduce grazing time and may upset the animals total forage intake. Thus, this method may not reflect accurately the intake of a normal animal.

Chromic oxide has also been administered with supplementary concentrates. Although this nullifies its use for purely grazing ruminants, it requires less handling and reduces grazing time only slightly without harassing the animal. This method has been used by Bloom (1957) who fed it in the concentrate portion of dairy cow rations four times daily and by Wheeler (1962) who fed it as a powder in cottonseed meal to beef cattle. Chromic oxide has also been mixed with the entire ration for dairy cows (Kane et al., 1952).

An approach somewhat similar to that of Corbett et al. (1958) involving the use of Cr_2O_3 dispersed on purified cellulose at a ratio of 60 parts to 39 parts with one part of aluminum sulphate added was reported by Wheeler (1962). This product is known as Cr_2O_3 cellulose. Other workers have used this method of administration with varying degrees of success (Raleigh, 1964, 1965; Alpan, 1965).

Pryor (1966), from the results of five experiments, confirmed that morning fecal samples have higher Cr_2O_3 concentrations than afternoon samples. Variation of these levels was influenced by frequency of dosing. Once or twice daily dosing with Cr_2O_3-cellulose did not result in uniform fecal Cr_2O_3 throughout the day. He further stated it is essential that workers in any particular environment establish their own correction factors and degree of variation. This cannot be done without total fecal collection studies which, because of their laborious nature, will generally restrict the number of animals observed.

It is obvious, from much of the conflict in the literature, that Cr_2O_3 results from one type of animal and one environment cannot be directly transferred to another. It appears that whichever form of Cr_2O_3 is found to be most suitable, consideration of time of dosing and sampling will be of importance.

Data are available where Cr_2O_3 has been dosed and feces collected more than twice daily (Brisson et al., 1957). However, dosing more than twice daily is quite impractical with grazing beef cattle, especially under range conditions or on land with low carrying capacity. Also, the time taken and disturbance of gathering cattle in larger areas interferes appreciably with normal grazing behavior. Thus, this part of the literature review will predominently emphasize research in which infrequent sampling and dosing were carried out.

Coup (1950) suggested taking grab samples from the rectum twice daily at tracer dosing times. Hardison and Reid (1953) demonstrated a definite diurnal variation in grazing cows which were given Cr_2O_3 at 7:30 am daily. There was a low point at 12 am and a peak at 6 pm. Kane et al. (1952) fed Cr_2O_3 in concentrates at 5 am and 1 pm and found peaks at 8 to 12 am and low points at 4 to 8 pm.

Smith and Reid (1955) reported that fecal output of grazing dairy cows was predicted as accurately when Cr_2O_3 was administered once daily as when given twice daily. However, Hardison et al. (1956) studying Cr_2O_3 excretion in dairy cows, reported more variability with once daily dosing compared to twice daily.

Comparing 24, 12 and 4 hr dosing, Pigden and Brisson (1956) found that frequency of administration had little or no effect on recovery. Grab sample Cr_2O_3 contents taken every 2 hr showed a wider range when sheep were dosed once daily (45 to 180%) compared to twice daily (65 to

135%). Putnam et al. (1958) suggested that once a day Cr_2O_3 administration, a 12 hr-grab-sampling schedule and four animals should result in digestibility values within $\pm 5\%$ of those obtained by the total collection procedure.

Davis et al. (1958) found considerable variations in Cr_2O_3 content of fecal samples throughout the day regardless of whether it was administered once or twice daily. Stevenson (1962) dosed cows with Cr_2O_3 in gelatin capsules at 6 am and 4 pm for 16 weeks. Fecal grab samples taken at 6 am and 4 pm gave a recovery rate of 92.6%. Thus, it can be seen that there is a conflict of opinion as to whether there is greater variation of fecal Cr_2O_3 excretion when dosing and sampling are done once daily compared to twice.

Ruggiero and Whelan (1977) reported work with white-tailed deer using Cr_2O_3 to predict fecal output. They concluded that a single grab sample would not yield an accurate estimate of total fecal output. But found that accurate estimates of total fecal output were obtained by combining the three-day mean estimate for fecal grab samples taken at two different times during each day. These times were 9 am plus 9 pm and 9 am plus 1 am.

Recent researchers have used Cr_2O_3 as a tool to determine fecal output and/or digestibilities of grazing ruminants. Rittenhouse _et al_. (1970) determined intake and digestibility of winter-range forage by cattle with and without supplements. Chromic oxide was incorporated in supplements formulated from varying amounts of soybean meal and corn or corn starch. Cattle received .10 g Cr_2O_3/kg $BW^{0.75}$/day. Five-day collection periods were preceded by 15-day preliminary periods. Fecal production was estimated from morning rectal grab sample concentrations of Cr_2O_3. Corrected fecal production in kg(Y) were computed from estimated fecal production (X) using an equation where $Y = 1.05\,X - 0.91$.

Thus, it appears that each researcher must determine the best time of day to collect grab samples and to feed the Cr_2O_3. Also equations need to be derived from preliminary studies which will allow estimated fecal production to be corrected. The only accurate way to do this is by total fecal collections and feeding diets similar to that encountered by the grazing animal.

Lignin. Lignin is a substance found in plant cell wall material which is insoluable in a solution of 72% sulfuric acid (Streeter, 1969). Pazur and DeLong (1948) suggested that lignin present in the earlier stage of plant growth is more readily digested than lignin in the more mature plants.

Theurer (1970) indentified three problems associated with the use of lignin as an indicator: (1) development of a simplified, repeatable technique for measurement of the indicator in forage and fecal samples, (2) obtaining forage samples with lignin content representative of that consumed by the animal and (3) constant, repeatable recovery in the fecal material.

Ellis et al. (1946) proposed the use of a 72% H_2SO_4 method for the determination of lignin. Using this technique for measuring lignin, researchers have obtained recoveries ranging between 86 and 105% with most falling in the high ninety's (Ellis et al., 1946; Forbes and Garrigus, 1950; Kane et al., 1953; Sullivan, 1955; Elam et al., 1962). A wider range in recovery of lignin (51 to 103%) has been obtained using the acid detergent method proposed by Van Soest (1963). Streeter (1969) concluded that the use of 72% H_2SO_4 for determining lignin content is reliable if proper isolation procedures are employed and if the lignin content of the consumed forage is greater than approximately 5%.

Representative forage samples have been obtained by hand clipping, esophageal fistulas and rumen fistulas. Considerable differences in lignin content have been noted between hand clipped and esophageal samples (Conner et al., 1963; Hoehne et al. 1967). Differences have also been noted between hand clipped and rumen samples (Lesperance et al., 1960; Ridley et al., 1963; Conner et al., 1963). McCann and Theurer (1967) reported that lignin content of rumen fistula samples averaged 68% higher than the average lignin content in the four major grass species available. In every instance, the fistula forage samples were higher than that of any single grass sample. Similar discrepancies in lignin content of rumen fistula and hand-fed forage samples have been reported by Lesperance et al. (1967).

Crampton and Maynard (1938) concluded that dietary lignin is not appreciably metabolized by animals after recovering 97.8 and 99.3% of the dietary lignin in the feces of rabbits and a steer, respectively. However, researchers do not agree on the undigestibility of lignin (table 1).

TABLE 1. REFERENCES REPORTING PERCENT FECAL RECOVERY OF LIGNIN

Reference	Method[a]	Lignin content	Recovery of lignin	S.E.[c]
		%	%	%
Lancaster (1943)	1	5.6	96	5.3
Ellis *et al*. (1946)	2	8.2	98	1.8
Davis *et al*. (1947)	2	6.2	86	7.7
Forbes and Garrigus (1948)	2	7.0	102	2.6
Forbes and Garrigus (1950)	2	6.9	105	2.2
Kane *et al*. (1953)	2	8.0	90	1.3
Balch *et al*. (1954)	2	8.3	95	0.6
Sullivan (1955)	2	7.4	92	1.7
Elam and Davis (1961)	2	...[b]	87	4.0
Elam *et al*. (1962)	2	...[b]	90	0.5
Balch *et al*. (1954)	3	7.0	99	0.8
Lesperance *et al*. (1967)	4	4.0	51	...[b]
Lesperance *et al*. (1967)	4	3.6	71	...[b]
McCann and Theurer (1967)	4	8.1	88	...[b]

[a]1-Crampton and Maynard (1938).
2-Ellis *et al*. (1946).
3-Armitage *et al*. (1948).
4-Van Soest (1963).

[b]Data not available.

[c]Standard error among rations in units of % lignin recovery.

Kane et al. (1952) reported considerable diurnal variation in the lignin content of feces. However, Elam and Davis (1961) found a coefficient of variation of only 2% among grab samples taken periodically throughtout the day. Incomplete recovery of lignin will bias intake predictions. For the lignin-ratio technique to accurately predict intake, an accurate estimate of lignin recovery is needed. Complete recovery is desirable, but it is not necessary since appropriate correction factors may be used effectively (Lucas, 1952) if percent recovery can be adequately determined. Van Dyne (1969) concluded that the lignin ratio procedure has given reasonable estimates of forage intake and digestion in most range studies when a good estimate was available for lignin composition of forage grazed. Church (1975) noted that even though lignin is often said to be indigestible, there are ample data (Hogan and Weston, 1969; Porter and Singleton, 1971) to show that very substantial losses of lignin may occur in the ruminant gastro intestinal tract, probably most of it in the rumen.

Nitrogen. The use of nitrogen as an internal marker has been questioned due to the high proportion of metabolic fecal nitrogen associated with fibrous plant species (Wilson et al., 1971). The sources of error in fecal index regression techniques have been summarized by Greenhalgh and Corbett (1960): (1) different herbages may have different nitrogen digestibilities for the same organic matter digestibility, (2) differences between animals exist in digestibility and (3) errors of measurement are important.

Lancaster (1949) is credited with the fecal nitrogen indicator technique, which employs relating herbage digestibility to concentration of nitrogen in the feces under a controlled trial. This equation is then used to estimate digestibility of herbage eaten by grazing animals from the fecal nitrogen concentration.

Minson and Raymond (1958) recommended that the prediction equation should be derived for the sward under study. They further proposed the use of sheep instead of cattle to derive the regression but commented that more comparative studies need to be done between cattle and sheep. Thomas and Campling (1976) compared the digestibility, voluntary intake and nitrogen concentrations in fecal organic matter in castrated male sheep and non-lactating cows offered herbage _ad libitum_. They reported similar concentrations of nitrogen in fecal organic matter and similar digestibilities of herbage organic matter in sheep and cows. They concluded that sheep could be used to derive equations for use with cattle.

Many equations have been developed which relate digestible organic matter and fecal nitrogen (Raymond, 1954; Greenhalgh _et al_., 1960; Minson and Keny, 1961; Langlands _et al_., 1963a; Greenhalgh _et al_., 1966) and the feed-to-feces ratio and fecal nitrogen (Lancaster, 1954; Lambourne and Reardon, 1962; Vercoe _et al_., 1962; Lambourne and Reardon, 1963; Hutton and Jury, 1964).

It has been shown that body weight influences metabolic fecal nitrogen (Schnieder, 1934). Blaxter and Mitchell (1948) contended that the fiber content of the feed also determines the ratio of metabolic fecal nitrogen to dry matter consumption. Researchers have shown that the nitrogen content of the feed is related to the nitrogen content of the feces only within a limited range (Gallup and Briggs, 1948; Homb and Breirem, 1952). Forbes (1949) found a steady increase in fecal nitrogen excretion per unit of dry matter intake as the protein content of the ration increased.

No significant diurnal variation of fecal nitrogen was found by Soni _et al_. (1954). Brisson (1960) found coefficients of variation of the concentration of nitrogen in fecal grab samples to be 7.5%. Lambourne and Reardon (1963) reported a diurnal variation in the fecal nitrogen grab sample of 7.0%.

Streeter (1969) concluded from the literature that prediction equations used in fecal index techniques are not consistent for forages obtained at different locations, at different seasons of the year and for different portions of the same plants. Thus, an equation derived from one series of control digestion trials with one group of harvested forages and one set of hand fed animals does not necessarily apply to different types of forages consumed by grazing animals. There appears to be no advantage in using other fecal index techniques over the fecal nitrogen index technique because of the larger error and/or increased complexity in the analysis. McManus _et al_. (1967) also concluded that there is no case for seeking more complex relations, with elements other than nitrogen, for the fecal index method for estimating forage intake.

Crude Fiber. Crude fiber has not received much attention as an indicator due to its being highly negatively correlated with digestibility (Richards and Reid, 1952). Raymond et al. (1954) found similar variability in the prediction of digestibility from the fiber chromogen or nitrogen content of feces. Raymond et al. (1955) questioned this technique because they found an inverse relationship between the percentage of fecal crude fiber and level of intake.

Indigestible Dry Matter (IDM). Indigestible dry matter can be determined by subtracting the digestible dry matter from one. If fecal output is known, the intake can be determined by the following equation:

$$\text{Intake}(g) = \frac{\text{Fecal Output}(g)}{\text{IDM}}$$

This procedure was presented by Van Dyne and Meyer (1964) and involves (1) determining the digestibility of range forage and a "standard" forage in the artificial rumen or by the nylon bag procedure using inocula from animals grazing the range forage, (2) predicting the digestion of range forage by regression from the artificial rumen or nylon bag adjusted to the digestibility of the standard forage and (3) use of the predicted digestibility, the composition of the forage, and the fecal output to determine forage intake.

The method of estimating forage intake from in vitro digestibility estimates has the advantage of being applicable to all stages of forage maturity while those based on chromogens or lignin are not always accurate at all stages (Harris et al., 1967). They further stated that the in vitro procedure requires more effort than the lignin ratio technique and that both methods require an accurate sample of grazed forage and accurate estimation of fecal output.

Van Dyne (1969) enumerated the sources of variation that exist in in vitro procedures including: (1) base feed of the animals from which inocula are obtained, (2) type and amount of buffer, (3) relative amounts of rumen liquor, substrate and energy source in media, (4) supply of vitamins and trace minerals, (5) particle size of samples, (6) length of fermentation and others. He further stated that no two laboratories use exactly the same procedures, and it may not be desirable that standardiztion takes place. Each laboratory must develop its own technique and consider or control the above variable.

Diurnal, daily, weekly and among-animal variations in ruminal microbe concentration and activity is evident (Williams and Christian, 1956). It has been shown, even under dry-lot feeding, that there are differences in ruminal microbe numbers due to feed treatments, animals, days, and also day X treatment interactions (Purser and Moir, 1959). Kamstra and Miller (1960) indicated that weekly variations are so great that they may completely mask seasonal changes. The fact that diurnal variation in numbers of microbes exists has been well documented (Hungate et al., 1960; Moore et al., 1962). The most uniform microbial conditions are generally found from 2 to 4 hr after feeding.

The source of inocula for in vitro studies has been investigated. It has been shown that the base diet greatly influences the magnitudes of in vitro digestibilities (Asplund et al., 1958; Clark and Mott, 1960; Taylor et al., 1960; Van Dyne, 1962). However, inclusion of a standard sample in each fermentation and adjusting all data to the standard may de-emphasize the importance of the base feed (Tilley and Terry, 1963; Van Dyne, 1963).

Van Dyne (1969) summarized the work of many investigators correlating artificial rumen or nylon bag digestibilities with those obtained by conventional procedures. He made the following general conclusions: (1) there is a high correlation between micro and macro digestion estimates for dry matter and cellulose, (2) the base feed of animals used as a source of inoculum is important, (3) in many instances 48 hr micro digestion estimates for cellulose are within 2 to 5% of the macro digestion estimate, (4) the micro digestion estimates are more precise and (5) better results generally are obtained when the same class of stock and feeds are used in both micro and macro digestion comparisons.

The literature offers no clear cut methods for the use of either internal or external markers. Various markers have shown more promise, ie., nitrogen, than others but there is still a great deal of controversy concerning there use. At this point in time, the only alternative available to the researcher is to decide which marker or markers yield the best results under controlled conditions. The time of sampling must be decided and the equations developed, then the system must be checked under grazing situations. If these methods cannot be relied upon to give accurate measurements, perhaps they can be useful for comparative measurements.

Production of Slaughter Weight Animals Utilizing Maximum Quantities of Forage and Minimum Quantities of Grain

As our population continues to increase, more of our productive agricultural land located near metropolitan areas may fall prey to urbanization. Thus, fewer acres are going to be expected to feed more people. The food production capabilities of the land are limited primarily because of the scarcity of energy and water. Cook (1977) stated that changing food production systems present the following concerns: (1) heavy capital investment, (2) long term credit, (3) high priced and scarce fossil fuel, (4) competition for grains between human consumption and livestock and (5) conflicts for land use for housing developments, highways, and for recreation such as scenic views, camping, picnicing, skiing and hiking.

The earth's population of 3.6 billion people is expected to double within the next 45 years. If agriculture is going to feed these extra people our land, water and fuel must be used as efficiently as possible. Currently, the resources being used at the fastest rate are our fossil fuels. There is a world wide concern for the increasing expenditure of fuel for food production.

Man may be able to conserve fossil fuels by consuming plant material derived from solar energy. For example, the production of food from corn (4.2) is much more efficient than the production from grain fed beef (.2) on the basis of average kilocalories of food produced for each kilocalorie of cultural energy expended (Cook, 1976). Cultural energy is the energy that supplements solar energy in the production of food.

Cook (1976) calculated that 5.33 kcal of cultural energy was required to produce a kilocalorie of dressed carcass in feedlot operations while the same steer fed on forage sorghums could be fed to good grade for an expenditure of 2.77 kcal of cultural energy. Thus, the steer fed on forage required 48% less cultural energy for production.

Over one-half of the total land area in the U.S. is rangeland which can be used effectively for the production of meat with minimum use of subsidized energy. These rangelands have no other alternate use for producing food other than through grazing and these lands have the potential of doubling current production (Cook, 1977). Intensification of management of this rangeland is a means by which we can increase production of animal protein for human consumption.

Intensifying the management of rangelands will not only yield an increased production but will also give the ranch operator more alternatives for marketing and managing his cattle. One possibility for a management alternative is through the retained ownership of yearling cattle utilizing improved rangeland such as crested wheatgrass (Agropyron desertorum) and irrigated pastures. The rancher can either grow these cattle to heavier weights, requiring less grain for finishing, or finish these cattle on grass with grain supplementation. This will of course involve wintering these calves, however research has shown that this can be done economically (Raleigh and Wallace, 1968). The rancher with a spring calving cow herd may have the potential for four alternate selling times. The most common one is weaned calves in late fall and the other three possibilities are light feeders in early spring, heavy feeders in mid-summer or slaughter weight cattle in late fall or early winter.

The work presented in this thesis deals with the foregoing alternatives, including finishing cattle in drylot utilizing low quality forage diets. The review of literature which follows deals with the various factors associated with these alternatives. These factors include (1) previous winters nutritional program, (2) growing period and supplementation of the forage, (3) finishing period, (4) carcass quality and characteristics of cattle fed low grain diets and (5) how the consumer views this type of beef from the standpoint of acceptability.

Previous Nutrition. What happens to the calf after weaning through the winter feeding program not only determines the profitability of the winter program but also affects subsequent gains in the growing period. Researchers agree that gains made following the wintering management period are inversely related to the winter gains (Peacock et al. 1964; Dahl and Denham, 1961; O'Donovan et al., 1972; Horton and Holmes, 1978).

Very few researchers report the previous gains or nutritional regime of the cattle they utilize in their studies. In order to accurately examine a feeding program, be it utilizing all-grain or all-forage diets, knowledge of the previous nutrition of experimental animals is needed. O'Donovan et al. (1972) concluded that the higher daily gains of bullocks on pasture previously wintered on a low plane of nutrition was largely the result of a significantly higher feed intake by these animals. Horton and Holmes (1978) also observed that compensatory gain paralleled increased intakes. Castle et al. (1961) found that rate of winter gain together with number of days on winter feed had a significant negative effect on subsequent summer gain. However, calves restricted to limited winter gains were considerably lighter at the end of the summer grazing period.

Raleigh and Wallace (1963) stated that weaner calves receiving low quality native meadow hay alone generally will do little more than maintain themselves through the winter period. Gains up to .68 kg per day are desirable. It has also been demonstrated that weaner calves will make better use of low quality meadow hay when additional protein is provided (Raleigh and Wallace, 1964). In comparing early-cut versus late-cut meadow hay fed weaners with two levels of additional energy, these researchers found that cost of gains for the steers receiving the early-cut hay with the higher level of energy was significantly less than for any other treatment.

In studies designed to compare the value of barley and meadow hay for wintering calves Raleigh and Wallace (1968) found that meadow hay was adequate for the maintenance portion of the diet and that it took three kg of barley to replace five kg of meadow hay. Returns over feed costs were greater for calves given the high roughage diet when sufficient supplemental protein and energy were provided to gain .64 kg per day.

Rate of summer gain was not affected by level of grain in the winter ration when gain was .68 kg per day (Raleigh et al., 1970). They found that returns over feed costs were greater for calves receiving higher amounts of barley during the winter period. The economic data favored a 4:5 barley for hay ratio, but feed conversion data indicated greater efficiency from the 3:5 barley for hay ratio. They accurately cautioned that the relative prices of barley, hay and the animal product should be used in determining the ration combination.

The rancher must continually make production decisions based upon the economic factors of animal value and prices of feedstuffs. The foregoing review indicates that ranchers can expect economical summer gains on pasture when economical winter gains have been made by weaner calves. The winter program needs to be supplemented with adequate energy and protein if low quality roughages are used. By feeding calves to gain .68 to .77 kg per day, the rancher can recover income above feed costs. This type of winter management will allow the rancher an alternative in the spring of retaining ownership or selling heavy calves which have recovered their feed costs.

Growing. Literature in the 1930's reported research conducted on fattening cattle on pasture (Moffett and Trowbridge, 1929; Bray, 1930; Good and Harris, 1930; Moffett, 1930; McCampbell, 1933; Sheets, 1933; Baker, 1934; Bray, 1934; Rinehart, 1936; Snell, 1939). Except for a few reports the literature is almost void of research concerned with utilization of forage diets by growing and finishing cattle until the late 1960's. Current concern over our ever increasing population and the possibility of grain shortages in the future has created a need for reevaluation of producing beef with a minimum use of grain.

The research emphasis prior to this time has been on crop production, high yielding acreages, and confinement or intensive feeding of livestock despite the fact that range contributes greatly in meeting our needs for red meat. Range can only contribute to the food supply of man by providing feed for grazing animals. More emphasis needs to be placed on production systems utilizing our rangeland which has the potential of sustaining or increasing our supply of red meat.

Unfortunately, all range forage species mature at about the same time with little difference in quality between species. The period from late June to early July is critical for ruminants with respect to digestible protein and digestible energy. After this period, these forage parameters drop below levels necessary to produce adequate gains of yearlings (Raleigh, 1970). Thus, an area of concern is the supplementation of digestible protein and energy for growing yearlings grazing range forage.

Supplemental Energy. Researchers in various parts of the U.S. working with different forages have found that supplemental energy will usually result in increased average daily gains in growing and fattening programs utilizing pasture (Raleigh, 1970; Edwards et al., 1968; Wise et al., 1967; Suman and Woods, 1966; Duncan, 1958). In order to efficiently maximize gains it is necessary to determine optimum supplemental energy needs. If grain is provided in excess of energy needs reduced forage intake occurs. This trade off of forage for grain will not maximize the use of roughage.

Raleigh (1970) evaluated range forage in terms of the extent to which forage nutrients meet the needs of different classes of livestock for various levels of production. Voluntary forage intake was determined with yearling beef cattle on the Squaw Butte Station range at two to four week intervals during the summer grazing period after chemical evaluation of the forage. Data indicate that protein becomes lacking about mid-June and energy in late June for yearling cattle expected to maintain a daily gain of one kg. Thus, supplement programs at this station are designed to provide the additional nutrients not available from the forage to maintain a desired daily gain. Chemical evaluation of the forage indicated high nutritive quality in the early part of the grazing season but studies show that dry matter intake was restricted during the period of high moisture content of the forage. It was therefore assumed that small amounts of an energy supplement in early spring would increase gains. Trials conducted to test this supposition indicated a significant increase in daily gain from early supplementation. Additional energy provided by barley (.3 kg/head) when moisture content of forage was above 60% increased daily gains by .2 kg per head.

Corn, grain sorghum and barley have been used to supply energy in supplement programs on pasture depending on location and grain availability (Utley and McCormick, 1976; Raleigh, 1970). Denham (1977) fed 1.24, 2.60, 3.96 and 5.32 Mcal metalbolizable energy in a corn supplement to steers grazing blue grama and western wheatgrass for 32 days during the spring grazing season. Each group received .12 kg per head of digestible protein from soybean oil meal. A control troup received no protein or energy supplement. Higher weight gains ($P<.05$) were made with energy supplementation than without. The greatest response was from the first increment of supplement. Energy supplemented steers gained less ($P<.05$) during the 132 day feedlot period following grazing. Data indicated that supplemental energy above 2.60 Mcal to yearling cattle during an extended grazing period offers very little in the way of increased gain or efficiency for either the producer or feeder.

Coleman et al. (1976) showed that gains on St. Augustine grass pastures were closely related to the amount of supplementation and that subsequent drylot gains were not depressed by the amount of supplement fed on pasture. They placed cattle in drylot at a pre-selected weight rather than after a certain number of days. Data support the theory that rate of gain in drylot is more dependent on body size than on previous rate of gain. Lake et al. (1974) also found a linear relationship between energy supplementation and grazing weight gains. They found no improvement in gain on irrigated pasture above 1.82 kg per head per day of corn. Time required to finish steers in the feedlot decreased with increased energy supplementation while grazing steers fed more supplement on pasture performed as well in the feedlot as those fed less.

Perry et al. (1971) fed cattle 0, 1/3, 2/3 and a full feed of concentrates on spring pasture. For each additional kilogram the cattle gained during the pasture season, they gained 0.2 kg less on the same daily concentrate during a drylot finishing phase. In a subsequent study employing the same levels of concentrate Perry et al. (1972) reported that increased concentrate feeding during the pasture phase resulted in linearly increased rates of gain ($r = .97$) for steers grazing spring plus summer pasture. Gains in the drylot finishing phase were negatively correlated with previous gains during the pasture phase. For each additional kilogram the cattle had gained during the pasture phase, they gained .29 kg less in the drylot phase. Furr and Sherrod (1965) also noted that supplemental feeding significantly increased pasture weight gains.

Protein Supplement. The following is a review of literature dealing with protein supplementation of growing animals grazing forage. During the early part of the grazing period protein content of actively growing plants is in excess of growing animal requirements. As the forage matures and growth ceases protein content of the forage drops rather rapidly. As the protein available goes below levels to maintain desired daily gains, research has shown that supplemental protein can be efficiently utilized by grazing animals (Raleigh, 1970; Probert and Lesperance, 1972).

Various protein supplements have been utilized by researchers for cattle consuming forage diets. Non-protein nitrogen supplements such as urea and biuret have been compared to natural protein supplements such as soybean meal or cottonseed meal. Raleigh and Turner (1968) compared biuret, urea and cottonseed meal as nitrogen supplements, with and without additional energy supplementation for growing heifers on range. Animals receiving biuret with a low level of energy gained 0.11 kg more per day than groups receiving either urea or cottonseed meal. When fed the low energy level, animals supplemented with biuret had the greatest economic returns followed by urea and cottonseed meal. Oltjen et al. (1874) compared feed grade biuret, urea and cottonseed meal as supplements with low quality chopped grass hay fed ad libitum for growing steers. Feeding biuret in a mineral mixture improved ($P<.05$) animal performance when the hay contained less than 6.0% crude protein (CP). Ammerman et al. (1972) working with sheep found that biuret plus an energy source gave a response similar to that obtained with either soybean or cottonseed meal. They also noted that positive nitrogen balance was obtained with supplemental nitrogen from urea, biuret, soybean meal and cottonseed meal. Johnson and Clemens (1972) fed biuret as a supplement with low quality prairie hay (4.5% CP) to fistulated wether lambs.

When biuret was the only supplemental nitrogen source maximum biuretolytic activity was achieved after 20 days.

Foonesbeck et al. (1975) in a review stated animal response is satisfactory when biuret is used to provide part of the nitrogen requirements. Response of ruminants to feed grade biuret was very good when fed with low quality forage diets deficient in nitrogen. The slow enzymatic hydrolysis of biuret in the rumen slows ammonia production. Thus, biuret is comparatively non-toxic and can be used at high levels in protein supplements and complete diets.

Biuret has been found to be a beneficial protein supplement on range (Probert and Lesperance, 1972; Raleigh and Turner, 1968) and under feedlot conditions utilizing silage rations (Meiske et al., 1969). Thus, it appears that biuret and urea can replace natural proteins for cattle grazing low quality roughage and that they may be less costly.

Finishing. The foregoing literature is concerned with supplementation of growing cattle utilizing maximum quantities of forage and minimum amounts of grain. These cattle which have received supplemental feed are carrying some degree of finish and can be continued onto slaughter. In order to further reduce the amount of grain fed to these cattle researchers have investigated various means of finishing cattle utilizing roughage sources.

All-forage finishing diets have been found to be more profitable than all grain diets (Utley et al., 1975). Utley and McCormick (1976) compared corn or grain sorghum for finishing steers in drylot or on rye grass pastures. Corn and sorghum gave similar average daily gains (1.56 vs 1.51 kg) and feed consumption (9.17 vs 10.01 kg) in drylot. When corn and sorghum were fed on pasture daily gains were similar (1.34 vs 1.36kg) and daily grain consumption was similar (5.91 vs 5.85 kg). The use of pasture decreased grain consumption by 38% as compared to the drylot. The drylot carcasses graded high good and the pasture carcasses graded low good.

Raleigh et al. (1967) compared performance of steers finished on crested wheatgrass range with steers finished in drylot receiving free choice meadow hay. All steers received the same amount of supplemental energy and protein. The supplement was gradually increased to 1.75% of body weight and remained there until slaughter. Previous nutrition was the same for all animals. The cattle fed in drylot gained significantly more than the range fed animals but cost per unit of gain was significantly lower in the range fed group. There were no significant differences in carcass grades or other measures of carcass quality.

Studies have been conducted utilizing all forage diets for finishing cattle in drylot (Oltjen et al., 1971; Dinius et al., 1978). Oltjen et al. (1971) compared alfalfa and timothy hay in various ratios for use as a pelleted feed. The growth response to alfalfa hay was superior to that of orchard grass ($P<.001$). Each additional increment of timothy hay substituted for alfalfa hay decreased ADG and increased total consumption. The carcasses from the steers in all groups graded medium to high good.

The use of irrigated pastures for growing and finishing cattle has also been investigated. Hull et al. (1967) compared rotational and continuous grazing on irrigated pasture in a three-year study using beef steers. They found that rotational grazing was better than, or equal to, continuous grazing in animal days grazing and liveweight gain per hectare at heavy stocking rates. Acord (1977), reporting on several years of data on irrigated alfalfa and alfalfa-grass pastures, concluded that properly managed pastures can bring a net return of $25.00 to $163.00 per acre including credit for labor. To obtain these returns, pastures should be: (1)grazed in rotation, (2) grazed intensively for four or five days, (3) allowed to rest and grow for 25 to 30 days before grazing again and (4) irrigated according to the plant's needs, usually every 14 to 21 days.

Palatability and Acceptability. Most studies have reported carcass data for steers finished on forage diets, but only a few reports are available concerning consumer preference of this type of beef. Acord (1977) stated that consumers will need to learn how to appreciate the advantages of meat that carries relatively little fat and, therefore, grades "Good" instead of "Choice". Brady (1957) found that the public prefers beef of U.S.D.A. good grade and would buy more of it, as compared to choice or prime grades, if it were available. Kidwell et al. (1959) found that tenderness and flavor of muscle and fat was not associated with carcass score and concluded that carcass grade does not have a great deal of influence on taste and acceptance of meat. Bowling et al. (1978) reported that the association between marbling and tenderness was relatively low ($R^2 = .09$).

Consumer acceptibility of forage-finished beef is controversial and only a few studies have been reported. Bowling et al. (1977) comparing 30 pairs of carcasses of essentially identical U.S.D.A. quality grades found that grain-finished beef was ($P<.05$) more tender, more desirable in flavor and more satisfactory in overall palatability than forage-finished beef. Bowling et al. (1978) used Santa Gertrudis steers slaughtered as calves, yearlings, long-yearlings and two-year-olds after periods on grass alone, grain on grass, or in drylot. He found that steers from grass alone or grain on grass were approximately six months older if slaughtered at comparable weight and grade than those fed in drylot after grazing and were lower and more variable in palatability.

Young and Kauffman (1978) assigned forty-two 362 kg yearling hereford steers to either a grain, corn silage or a 50-50 haylage-corn silage (dry basis) finishing diet. All steers were slaughtered when the mean ultrasonic fat thickness scan was about 1.0 cm at the twelth costae. Organoleptic evaluations of steaks and roasts indicated that for the quality attributes of tenderness, juiciness, flavor and overall desirability, panelists rated the corn silage and haylage-corn silage finished groups equal to or superior to steers fed grain. These data are interpreted to indicate that when steers are fed to similar levels of carcass composition rather than weight, palatability of meat is comparable whether the diet is grain or forage.

Researchers from Louisiana (Schupp et al., 1976a,b) have put together a report on consumer acceptance of forage-finished and limited grain-finished beef. Schupp et al. (1976b) reviewed research results from state experiment stations evaluating the acceptability of forage-finished and limited grain-finished beef. Mississippi, Kentucky, Colorado, Wisconsin and Louisiana results have shown little advantage for grain feeding. However, Missouri, Kansas and Texas researchers have reported superiority in acceptance of grain-finished beef. Forage-finished beef was satisfactory in each case based primarily on sensory panel evaluations.

Schupp and co-workers (1976a) made the following implications to the beef producer, the meat packer, the retailer and the consumer based upon results of their study: (1) Louisiana beef producers desiring to market forage-finished or limited grain-finished animals should attempt to market directly to a meat packer or to a retailer having access to a consumer market acquainted with beef meeting less than choice grade standards. (2) Results indicate that retail purchasers were not concerned with the degree of fat color exhibited by LSU animals. Hence, rejection or price discounting by the meat packer of forage-finished cattle on the basis of fat color does not appear to be justified. (3) Since consumers have differing tastes and preferences, retailers should be aware that good grade beef is acceptable to or preferred by many consumers. Through judicious use of price discounting, forage-finished and limited-grain-finished beef can usually be marketed at returns sufficient to cover costs with acceptable profit margins. (4) The consumer should realize that forage-finished and limited-grain-finished beef is not available in most food stores. Limited availability can be found in specialized meat markets and in smaller independently owned food stores. Forage-finished beef can be easily over-cooked by dry cooking methods due to a lower content of internal and external fat.

The value of a slaughter beef animal is dependent upon the quality and quantity of meat in the carcass plus the value of the by-products. One of the valuable by-products of beef is the liver. It has been found (Haskins _et_ _al_., 1967) that high concentrate feeding produces a large percentage of abcessed livers which are condemned and that roughage feeding reduces this loss.

The work done on supplementing steers on pasture or other forage diets agrees that supplementation increases animal performance on all types of roughage. Research indicates that supplements have to be adjusted upward during the grazing season so that the decreasing nutrients from the forage are replaced by the supplements. It is possible to finish steers on all forage and limited grain diets to acceptable carcass quality with less incidence of abcessed livers. However, the palatibility and consumer acceptability of this beef is controversial.

Further work needs to be done with forage-finished and limited-grain-finished beef. Future research should not stop at slaughter but continue to the consumer. More preference data needs to be gathered on this type of meat as well as marketing data.

COMPARISON OF VARIOUS INTERNAL INDICATORS AND CHROMIC OXIDE TO ESTIMATE FORAGE INTAKE AND FECAL PRODUCTION

COMPARISON OF VARIOUS INTERNAL INDICATORS AND CHROMIC OXIDE TO ESTIMATE FORAGE INTAKE AND FECAL PRODUCTION[1]

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SUMMARY

The chromic oxide (Cr_2O_3) technique was used to determine individual fecal output of six 208 kg steers fed five different ratios of barley to hay. Total daily fecal output derived from grab samples collected at 0700, 1200, 1700 and composite samples were correlated to actual daily fecal output. Respective correlation coefficients were .63, .59, .80 and .79. The average recovery of Cr_2O_3 for the entire study was $94.05 \pm 3.91\%$. Estimates of forage intake using lignin (L), crude fiber (CF), nitrogen (N) and indigestible dry matter (IDM) were correlated to actual forage consumption with the respective coefficients (r) of .92, .93, .96 and .89. No significant differences were found between collection times of 0700, 1200, 1700 and the composite sample for L, CF or N estimates of forage consumption. Estimates of forage consumption were most accurately predicted by the L and CF methods. (Key Words: Indicators, Fecal Production, Forage Intake, Chromic Oxide, Lignin, Crude Fiber, Indigestible Dry Matter.)

INTRODUCTION

A reliable method of predicting forage intake is needed as a tool for researchers to evaluate the nutrient consumption of grazing animals. Various methods have been reported with varying degrees of success.

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External indicators, those originating outside of the feed source, have been utilized as an aid in predicting fecal output which is necessary for estimating forage intake. Chromic oxide, iron oxide, mineral salts, metal or plastic particles and dyes have been used to predict fecal production (Kotb and Luckey, 1972).

Pryor (1966) used fecal bags to collect excreta and noted considerable discomfort to the animals. This type of distraction and discomfort may cause some alteration in normal grazing patterns and reduce daily gains.

Internal indicators are substances which occur naturally within the forage. These include lignin, crude fiber, chromogens, silica, nitrogen and cell wall constituents. Forage intake can be estimated from the relationship between forage and fecal concentrations of the internal indicators once fecal output is known.

This study was designed to determine the diurnal fluctuation of Cr_2O_3 and the optimum time to obtain representative fecal samples with intent of applying these results to the grazing situation in subsequent trials. L, CF, N and IDM as estimators of forage intake were also evaluated.

MATERIALS AND METHODS

Six steers averaging 208 kg were individually confined on 2.4 x 3.6 m pads. Each steer had access to 3.6 m of bunk space and was provided water in 40 liter buckets. Barley was fed in plastic pans approximately 30.4 x 30.4 x 15.2 cm deep. The trial comprised five feeding periods with barley to meadow hay ratios of 1:10, 1:5, 1:1, 1.5:1 and 2.5:1.

Chromic oxide was mixed with fine ground barley. The Cr_2O_3 concentration fed during periods 1 and 2 was 13g/227g of grain and for periods 3, 4 and 5 was 10g/227g of barley. Steers were fed the Cr_2O_3 mixture at 0700 daily for 10 days prior to the first collection period and continually throughout the trial. Each collection period was three days long with at least four days between periods to allow for adaptation to the new grain to forage ratios.

Daily fecal production was determined by collecting and weighing feces from the concrete pad. After thorough mixing of the daily excrement, a composite sample was taken for each steer. Grab samples were randomly taken from fresh excreta at 0700, 1200 and 1700 hours. Grab samples from each steer were combined for the three-day collection period so that 0700, 1200 1700 and composite samples were analyzed for each period. Grain, hay and fecal samples collected during each period were oven dried at 45 C prior to chemical analysis. Grain and hay samples were analyzed for L, CF and N. The fecal samples were analyzed for Cr_2O_3, L, CF and N. Fecal production for each steer was estimated for the 0700, 1200, 1700 and composite samples using the following equation:

$$\text{Daily fecal production(gDM)} = \frac{\text{indicator consumed(g/day)}}{\text{indicator conc. in feces(g/g)}}$$

Forage intake was determined by the following equation which accounts for grain consumption:

$$\text{Forage intake(gDM)} = \frac{\text{feces (g) X conc. of indicator (g/g)} - \text{grain (g) X conc. of indicator (g/g)}}{\text{conc. of indicator in the forage (g/g)}}$$

Dry matter digestibility was determined for hay and grain samples by a modification of the _in vitro_ method of Tilley and Terry (1963). Chromic oxide content was determined using the method described by Bolin _et al_. (1952). Nitrogen, CF and 72% L were analyzed by the A.O.A.C. method (1970). Data were subjected to analysis of variance and LSD mean comparisons to determine if sampling times were significantly different. Relationships between actual and estimated fecal production and actual and estimated forage intake were determined by regression analysis (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

Mean recovery of Cr_2O_3 and the standard error are given in table 1 for each period. The mean overall recovery for the entire study was $94.05 \pm 3.91\%$. This recovery rate is comparable to those of other researchers using Cr_2O_3 (Corbett _et al_., 1958; Pryor, 1966; Nelson and

Green, 1969). Barnicoat (1945), working with Cr_2O_3, noted problems with incomplete recovery.

TABLE 1. CHROMIC OXIDE RECOVERY (%)

Period	1	2	3	4	5
Recovery (mean)	89.50	90.06	98.92	95.34	98.14
(s.e.)*	11.46	9.22	12.81	13.92	8.81

*P<.05.

Each steer's estimated fecal production for the 0700, 1200, 1700 and composite samples was correlated to that animal's measured fecal production. Table 2 presents the respective correlation coefficients and F values. The 0700 and 1200 collections gave the poorest predictions of fecal production with the 1700 and composite samples being the best predictors of fecal output. The mean of the 1700 sample was greater (P<.05) than the 0700 or composite sample means but not significantly different from the 1200 sample mean.

TABLE 2. DAILY FECAL PRODUCTION ESTIMATES USING Cr_2O_3

Sample	Mean	r	F
0700	1884.6[c]	.63	16.72**
1200	2240.7[ab]	.59	13.94**
1700	2323.4[a]	.80	45.37**
Composite	20.58.2[bc]	.79	42.82**

[abcd]Means having different superscripts are significantly different at (P<.05).

**P<.01.

Diurnal fluctuations of external markers such as Cr_2O_3 have hindered their use as predictors of fecal production (Raymond and Minson, 1955; Putnam et al., 1958; Hayes et al., 1964). Keisling et al. (1969) obtained the highest average recovery (79.5%) at 1700. This recovery was significantly higher (P<.05) than the recoveries for 0500 through 1500.

Rittenhouse et al. (1970) used morning ractal grab samples to estimate total fecal production. Putnam et al. (1964) took fecal grab samples at 0900 and 1500. Each researcher using Cr_2O_3 needs to determine the best time of collection based on the conditions of his work.

Care must be taken in extrapolating confined feeding trials to grazing trials as pointed out by Raymond and Minson (1955). The results of this study illustrate the problems encountered in utilizing Cr_2O_3 as a dependable marker to predict fecal excretion. They found that fluctuations in the field ranged from 70% to 130% of the mean, as compared to 85% to 120% for indoor feeding. Before utilizing this technique in the field, it must be tested under grazing conditions.

Table 3 gives the r values obtained when actual hay intake was correlated with predicted hay intake using L, CF and N as internal indicators. It appears that these forage constituents may be used to predict hay intake. Analysis of variance indicated that there were no significant differences between collection times for L, CF or N. When comparing the 1700 hr collections, the mean and standard error ($P<.05$) for intakes predicted by L, CF and N were 3243 ± 478, 3240 ± 382, 3244 ± 1407, respectively. The mean and standard error of actual forage intake was 3244 ± 542. The L and CF methods appear to predict forage intake with more precision than the N technique.

TABLE 3. UNADJUSTED FORAGE INTAKE MEANS[a] AND CORRELATION COEFFICIENTS

	Mean (r)		
Sample	L	CF	N
	g	g	g
0700	3749 (.95)	1389 (.94)	206 (.96)
1200	3817 (.96)	1360 (.94)	232 (.95)
1700	4025 (.93)	1401 (.93)	327 (.96)
Composite	3908 (.92)	1402 (.93)	259 (.96)

[a]LSD ($P<.05$) values were 1183, 356, and 832 for L, CF and N, respectively.

Indigestible dry matter was also used to predict the hay intake by the following equation:

$$\text{Forage Intake (g)} = \frac{\text{Fecal output (g)} - (\text{grain (g)} \times \text{grain IDM})}{\text{Forage IDM}}$$

Indigestible dry matter is equal to one minus the percent digestibility as determined by the _in vitro_ technique. The correlation coefficient for predicted to actual hay intake was .89. The lower r value as compared to L, CF and N would indicate less accuracy in predicting forage intake with the IDM method.

The methods described in this study were used to measure intake of grazing steers. A large variation in the Cr_2O_3 excretion was obtained which increased the error in predicting the forage intake. In order to utilize these methods under grazing conditions, prediction equations must be determined on the range. Caution is given in extrapolating results obtained under confined feeding conditions to the grazing situation.

The results of this confined feeding trial indicate that the L, CF, N or IDM technique can be utilized to estimate hay intake with varying degrees of precision. However, extrapolating this data to the grazing animal without further testing under grazing conditions may result in erroneous estimates of forage consumption. As noted by Theurer (1970), the validity of these techniques depends upon collection of forage samples representative of the animal's diet and a representative fecal sample. The _in vitro_ digestibilities of hay used in this study ranged from 47.8% to 52.0%. The digestibility of range forage is higher in the spring and lower in the fall. Thus, the L, CF and N components may also vary to a greater degree than under the controlled conditions of this trial.

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COMPARISON OF METHODS OF PRODUCING SLAUGHTER WEIGHT STEERS USING MAXIMUM QUANTITIES OF FORAGE AND MINIMUM QUANTITIES OF GRAIN[1,2]

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SUMMARY

Three trials were conducted using a total of 129 Hereford or Hereford X Angus steers. Trials 1 and 2 evaluated the performance of steers on irrigated pasture and crested wheatgrass during the growing phase. The steers were allotted to various finishing regimes from the growing study. These included finishing on irrigated pasture, on range and in the feedlot using two 40% roughage based rations for trial 1 and four 40% roughage based rations in trial 2. Trial 3 was conducted using fall born steers which were either immediately sent to the feedlot and fed two 38% straw based rations, put on irrigated pasture prior to going to the feedlot or grazed on irrigated pasture, wintered on a 100% forage diet of 2/3 alfalfa and 1/3 grass hay and then finished on crested wheatgrass range the following spring.

Steers gained faster ($P<.05$) on range than on either the alfalfa-fescue or clover-fescue irrigated pastures of trial 1 and 2. Steers finished on irrigated pasture and range made greater daily gains than the steers receiving the 40% roughage rations in the feedlot in trial 1.

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[2]Technical Paper No. 4916 , Oregon Agricultural Experiment Station.

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COMPARISON OF METHODS OF PRODUCING SLAUGHTER WEIGHT STEERS USING MAXIMUM QUANTITIES OF FORAGE AND MINIMUM QUANTITIES OF GRAIN

In trial 2 the feedlot steers gained faster with the range steers gaining the least ($P<.05$). In both trials 1 and 2 the feedlot groups had greater ($P<.05$) 24-hr shrunk carcass weights due to a longer feeding period. Carcass grades were lowest for the alfalfa-fescue irrigated pasture group in both trials. Overall desirability of the beef was greatest for the feedlot groups in both trials.

Daily gains were lowest ($P<.05$) for the fall-born steers finished on crested wheatgrass (trial 3). Carcass weight, grade and marbling scores were not significantly different between treatments. Less than 86 kg of barley was used to produce slaughter weight steers from crested wheatgrass range under the management of trial 3.

INTRODUCTION

The probability of high grain prices and/or a shortage of grain for livestock feeding due to human competition has created a need for reevaluation of finishing cattle with a minimum use of grain. By necessity, cattle feeding may become more dependent upon range and pasture forage. Therefore, rangelands may again be looked to as a source of slaughter cattle.

The majority of the semi-arid and arid rangelands of the west have no alternate use for food production other than through grazing. It is important that our ranges and meadowlands be utilized to the fullest extent for meat production which will conserve feedstuffs that can be consumed directly by man. Production of a slaughter weight animal, which is acceptable to the consumer, utilizing a maximum quantity of forage and a minimal quantity of grain is needed to insure that beef will continue to be an economical protein source for the consumer.

The objectives of this study were to compare performance and slaughter characteristics of various production systems by which slaughter steers can be produced in the high desert rangeland of eastern Oregon. Economic analysis and taste panel evaluations are also included.

MATERIALS AND METHODS

Trial 1. Sixty Hereford steers, with an equal number from each of four winter treatments, were assigned to a growing and finishing study on May 11, 1976. Steers were stratified by previous winter treatment and randomly allotted to one of three growing phase treatments. Thirty-six steers were assigned to a crested wheatgrass (Agropyron desertorum) range and 24 split between alfalfa-fescue (Medicago-Festuca) and clover-fesxue (Trifolium-Festuca) irrigated pastures.

Steers on the range treatment, during the growing phase, were moved to a fresh pasture when they had utilized about 35% of the available forage as determined by visual observation. A supplemental feeding program for yearlings on crested wheat developed over a period of years on the Squaw Butte Station was used as a base (Raleigh, 1970). Table 1 shows the daily supplemental nutrient intake of the steers on range. Energy and nitrogen were supplied by barley and biuret, respectively. Careful attention was given to hand feeding the supplement at the same time each morning in order to maintain maximum grazing time and performance. Steers on irrigated pasture were alternated between two pastures, approximately .81 ha in size. Steers were moved every two weeks to allow for irrigation and regrowth. These animals received 1.45 kg of barley per head through July 28 at which time barley was gradually increased to 2.27 kg by August 3.

The finishing phase began August 3 at which time 10 steers from the range treatment and five from each irrigated pasture treatment were assigned to the feedlot. One-half of the steers placed in the feedlot received a 40% roughage (38% rye grass straw, 2% alfalfa) based ration with cottonseed meal (CSM) as the source of protein. The other half received basically the same ration with dried poultry waste (DPW) and feathermeal as the protein source. These rations are shown in table 2. Steers were slaughtered when back fat reached 7.6 mm as measured by ultrasonic means and carcass data were collected.

TABLE 1. DAILY SUPPLEMENT INTAKE ON RANGE

Period	Supplemental nutrient[a] Nitrogen (g)	Digestible energy (kcal)
5/11-6/15	7.8	1640
6/16-6/17	13.2	1640
6/18-6/19	14.4	1640
6/20-6/26	17.2	1640
6/27-7/3	23.2	1640
7/4-7/10	28.5	2102
7/11-7/17	34.0	2569
7/18-7/24	38.4	2873
7/25-8/3	44.2	4146

[a]Biuret and barley were used as supplemental sources of N and DE. While extra N was not considered necessary between 5/11 and 6/16 the barley provided small amounts as indicated.

TABLE 2. FEEDLOT RATIONS FOR STEERS, TRIALS 1 AND 3

Ingredient	CSM(kg)	DPW(kg)
Straw, rye grass	340.9	340.9
Alfalfa	22.7	22.7
Molasses	68.2	68.2
Tallow	22.7	22.7
Rolled barley	347.3	351.3
Cottonseed meal	102.2	---
Dried poultry waste	---	84.0
Feather meal	---	18.2
Limestone	4.0	---
Antibiotic	.45	.45
Vitamin A premix[a]	.45	.45
Total	908.90	908.90

[a]4.4 million IU/kg.

[b]CSM and DPW are cottonseed meal and dried poultry waste rations respectively.

Steers remaining on crested wheatgrass range and irrigated pasture received increasing amounts of grain at the rate of 227 g every two days until they reached a full feed of grain, using the pastures and range as a roughage source. When the level of grain reached 3.6 kg daily per head, the steers were fed half their daily allowance morning and evening. Composition of rations for the finishing phase are shown in table 3. It was necessary to feed grass hay to steers on irrigated pasture the last 31 days after frost stopped growth. The steers were slaughtered beginning November 6, prior to the onset of cold weather which reduces feed efficiency. The ten heaviest range steers were slaughtered at this time. The ten heaviest steers from irrigated pasture treatments were slaughtered November 13 and the next ten heaviest animals on range were slaughtered November 20. Carcass data were collected on each of these animals.

TABLE 3. FINISHING RATIONS FOR STEERS ON IRRIGATED PASTURE AND RANGE, TRIALS 1 AND 2

Ingredient	Irrigated Pasture (kg)	Range (kg)
Rolled barley	891.8	880.9
Biuret	3.6	11.4
Salt	9.1	7.3
Limestone	4.5	9.4
Vitamin A premix[a]	.45	.45
Total	909.45	909.45

[a]4.4 million IU/kg.

Sensory panel evaluations were made on the longissimus muscle from the 9-10-11-12th rib section of five randomly chosen carcasses from each treatment. The cuts were placed in plastic bags, the air evacuated, over wrapped with freezer paper and frozen whole. Just prior to cooking and sensory evaluations, the frozen cuts were removed from the freezer. As thin a full cut as possible was taken from the small end and then three one-and-one-quarter inch steaks were cut. The steaks were cooked in the frozen form by broiling ten minutes on each side at which time thermocouples were inserted into the middle of the steak and broiling continued with turning every five minutes until an internal temperature of 71 C was reached. Warm samples (two per cut) were served to individual panelists on a ten member trained taste panel. Tenderness, flavor, juiciness and overall desirability were ascertained using an eight point structured hedonic scale. Intensity of aroma was scored on an unstructured scale.

Trial 2. Thirty-nine Hereford and Hereford X Angus steers were assigned to a growing and finishing study on May 17, 1977. Eighteen head were allotted to crested wheatgrass (*Agropyron desertorum*) range, 10 head to alfalfa-fescue (*Medicago-Festuca*) irrigated pasture and 11 head to alfalfa-orchardgrass (*Medicago-Dactylis glomerata*) irrigated pasture. Steers were managed and fed as in trial 1, except the steers on irrigated pasture received 1.14 kg of barley daily per head.

The finishing phase began August 3 at which time nine steers from range, five from alfalfa-fescue and six from alfalfa orchardgrass irrigated pasture were allotted to one of four feedlot treatments. Each of the feedlot treatments was a 40% roughage based ration of either 5% alfalfa hay plus 35% annual rye grass straw (ARS), 35% perennial rye grass straw (PRS), 35% wheat straw (WS), or 35% grass hay (GH) (table 4).

The nine steers remaining on crested wheatgrass range were managed and fed as in trial 1. The 10 steers remaining on irrigated pasture were placed in drylot and fed long meadow hay *ad libitum* with the grain ration fed as in trial 1. Composition of steer rations for range and irrigated pasture were the same as fed in trial 1 (table 3). The steers from the irrigated pasture study were removed for slaughter on November 6. The crested wheatgrass steers were removed on November 20. Sensory panel evaluations were conducted as previously described.

Trial 3. Thirty Hereford and Angus X Hereford steers born in the fall of 1975 were assigned to various growing and finishing treatments at weaning time, July 28, 1976. Ten steers were assigned to go to the feedlot immediately, five of which were placed on the CSM ration and five on the DPW ration (table 2). The remaining steers were allotted to irrigated pasture until October 12. At this time ten went to the feedlot where half were placed on the CSM ration, the rest on the DPW ration. These treatments will be referred to as IP-CSM and IP-DPW.

TABLE 4. FEEDLOT RATIONS FOR STEERS, TRIAL 2

Ingredient	ARS(kg)	PRS(kg)	WS(kg)	GH(kg)
Annual rye grass straw	159.1			
Perennial rye grass straw		159.1		
Wheat straw			159.1	
Grass hay				159.1
Alfalfa	22.7	22.7	22.7	22.7
Rolled barley	310.4	310.4	310.4	310.4
Feather meal	11.4	11.4	11.4	11.4
Cottonseed meal	11.4	11.4	11.4	11.4
Tallow	22.7	22.7	22.7	22.7
Molasses	68.2	68.2	68.2	68.2
Limestone	6.4	6.4	6.4	6.4
Tricophos	.45	.45	.45	.45
Rumensin premix[a]	.45	.45	.45	.45
Vitamin A premix[b]	.45	.45	.45	.45
Total	454.55	454.55	454.55	454.55

[a]44 g/kg.

[b]4.4 million IU/kg.

The other ten steers were assigned to be fed approximately two-thirds alfalfa hay and one-third meadow hay through the winter period in drylot. They also received .45 kg barley per head each day the last 90 days in the lot. On May 18, 1977, they were placed on crested wheatgrass range until July 17, at which time they were removed for slaughter. While on crested wheat they received .91 kg barley daily per head plus biuret as prescribed by the supplement schedule of table 1. This treatment is referred to as IP-SB-CW. Carcass data were collected for all five treatments.

Data were subjected to analysis of variance. Significance ($P<.05$) between means was determined by LSD procedures as outlined by Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

Trial 1. Performance and economic analysis of steers during the 84-day growing phase are shown in table 5. Steers grazing the crested wheatgrass range gained faster ($P<.05$) than either group on irrigated pasture on approximately one-third the grain. It is possible that increased gains could have been obtained by feeding more concentrate (Perry et al., 1972). However, successive increments of grain usually return less gain per additional unit as shown by Denham (1977).

TABLE 5. GAIN AND CONSUMPTION DATA FOR 84-DAY GROWING PHASE OF TRIAL 1

	Irrigated Pasture		Range
Item	Alfalfa-fescue	Clover-fescue	Crested wheat
No. of steers	12	12	36
Initial wt, kg	200	201	198
Daily gain, kg	1.11[a]	1.08[a]	1.49[b]
Daily grain intake, kg	1.51	1.51	.59
Grain/gain ratio	1.36	1.40	.39
Economic Analysis			
Receipts			
Feeder steers, $[c]	205.22	204.59	225.05
Expenses			
Growing steers, $[d]	176.00	176.88	174.24
Feed cost, $[e]	36.34	36.34	26.99
Total expense, $	212.34	213.22	201.23
Returns to capital, land, labor and mangement, $	-7.12	-8.63	23.82

[ab]Means bearing different superscripts are significantly different ($P<.05$).

[c]Valued at 70¢/kg.

[d]Valued at 88¢/kg.

[e]Barley at 12.1¢/kg. Forage at $7.50 per steer month.

Returns to capital, land, labor and mangement were greatest for the range steers. Fewer mangement problems were encountered with range steers than those on irrigated pasture due to fewer parasite and health problems.

Steers finished on irrigated pasture gained faster ($P<.05$) than those finished in the feedlot (table 6). Daily feed intake, which did not include grass for the range or irrigated pasture treatments, was nearly twice as much in the feedlot. The additional five kg of feed required per head in the feedlot illustrates the contribution of the pastures for finishing the range and irrigated pasture steers. Utley and McCormick (1976) reported that the use of pasture decreased grain consumption by 39% as compared to the drylot. By finishing steers on range and irrigated pasture, a savings of 86 kg of grain was made as compared to finishing under this type of a feedlot program. The actual savings is somewhat greater as 17 days of feed are not accounted for in the feedlot treatments. This period was allowed for steers to recover from transport and get back on feed. This illustrated another advantage of finishing on range as the cattle do not go through a period of being off feed.

Weather conditions dictate the length of time cattle can remain on pasture, thus, restricting the feeding period and body weights attainable. This is illustrated in the heavier ($P<.05$) carcass weights of the feedlot animals which received an additional 27 days of feed as recorded plus the 17 days prior to the finishing phase beginning. Carcass grades were also higher from the feedlot which may also be due to the additional days on feed and not the type of feed. Fat color of the carcasses from irrigated pasture were more ($P<.05$) yellow than those from the range or feedlot. Rib eye areas were not significantly different among treatments. Beef from the feedlot group was more desirable ($P<.05$) in all factors of the taste panel evaluation except in aroma where no differences occurred. The overall desirability of cattle in the DPW feedlot treatment was greater ($P<.05$) than the CSM treatment.

TABLE 6. PRODUCTION AND CARCASS CHARACTERISTICS FOR FINISHING PHASE IN TRIAL 1

Item	Irrigated Pasture		Range	Feedlot[i]	
	Alfalfa-fescue	Clover-fescue	Crested wheatgrass	CSM	DPW
No. of steers	6	6	25	10	10
Initial wt, kg	301	302	321	330	329
Daily gain, kg	1.36[a]	1.35[a]	1.16[ab]	.91[c]	1.02[bc]
Daily feed intake, kg[d]	5.11	5.11	5.47	9.07	10.57
Feed/gain ratio	3.76	3.79	4.71	9.97	10.36
Days on feed	103	103	103	130	130
Carcass characteristics					
24 hr carcass wt, kg	236[a]	238[a]	253[a]	276[b]	284[b]
Carcass grade[e]	7.6[a]	8.2[ac]	9.2[ab]	10.3[b]	10.1[b]
Marbling score[f]	3.20[a]	3.4[ab]	3.75[ab]	4.1[b]	4.1[b]
Rib eye area, cm	24.55	26.79	24.27	26.16	26.11
Fat color[g]	2.6[a]	2.4[a]	3.5[b]	4.0[c]	4.4[c]
Taste panel evaluation[h]					
Aroma	4.62		4.58	4.37	4.37
Tenderness	3.95[a]		4.47[b]	5.63[c]	6.35[d]
Juiciness	4.69[a]		4.83[a]	5.45[b]	5.94[c]
Flavor	4.86[a]		4.94[a]	5.81[b]	6.20[c]
Overall desirability	4.31[a]		4.70[b]	5.61[c]	6.31[d]

[abc]Means within a row bearing different superscripts are significantly different ($P<.05$).

[d]Intake does not include forage for irrigated pasture and range treatments.

[e]13 = medium choice, 10 = medium good, 7 = medium standard.

[f]4 = slight, 3 = traces.

[g]4 = slight yellow tinge, 3 = slightly yellow, 2 = moderately yellow;

[h]Scored on a scale of 1 to 8 with 8 being most desirable.

[i]CSM and DPW are cottonseed meal and dried poultry waste treatments respectively.

Trial 2. Performance characteristics and economic analysis of the growing phase are shown in table 7. The daily gains were much less than gains of steers in trial 1. Steers used in trial 2 were approximately 75 kg heavier at the beginning due to higher winter gains than the animals of trial 1. The lighter animals of trial 1 exhibited compensatory growth which boosted their daily gains. The steers on the alfalfa-fescue irrigated pasture treatment gained the least ($P<.05$) as compared to the other two treatments. The steers on crested wheatgrass received approximately half the amount of supplement as those on irrigated pasture. Returns to capital, land, labor and management were again the highest for the range steers.

Production and carcass characteristics for the finishing phase are shown in table 8. Daily gain on crested wheatgrass was less ($P<.05$) than the other treatments. The irrigated pasture steers which were finished on meadow hay fed free choice in the lot had greater ($P<.05$) daily gains than those on range. Raleigh et al. (1967) reported steers finished in drylot being fed meadow hay ad libitum gained more ($P<.05$) than the range-fed group. Days on feed for the feedlot treatments would have been 30 days longer except that the cattle went off feed and the trial was restarted at the point when they were back on feed again, thus the difference in initial weight. This inflated the daily gains of the feedlot steers, as the time the steers were recovering from shipment and getting back on feed was omitted. Daily feed and hay intake of the steers from irrigated pasture was greater than any of the 40% roughage rations in the feedlot. However, the steers from irrigated pasture consumed over half of their diet as roughage. A savings of 60 kg of grain per head was possible by finishing steers in the feedlot as compared to range and irrigated pasture.

Carcass weights were again heavier from steers out of the feedlot. No significant difference was found in carcass grade or marbling score. The ARS and PRS carcasses had larger ($P<.05$) rib eye areas than either the alfalfa-orchardgrass or the crested wheatgrass treatments. Other treatment differences were not significant. Fat color was somewhat more desirable in the feedlot treatments. Overall desirability of the beef from the crested wheat treatment was lowest ($P<.05$). This effect was

TABLE 7. GAIN AND CONSUMPTION DATA FOR GROWING PHASE OF TRIAL 2

Item	Irrigated Pasture: Alfalfa-fescue	Irrigated Pasture: Alfalfa-orchardgrass	Range: Crested wheat
No. of steers	10	11	18
Initial wt, kg	281	271	282
Daily gain, kg	.70[a]	.90[b]	.92[b]
Daily grain intake, kg	1.14	1.14	.61
Grain/gain ratio	1.62	1.27	.66
No. days	76	76	78
Economic Analysis			
Receipts			
Feeder steers, $[c]	233.94	237.72	247.77
Expenses			
Growing steers, $[d]	216.37	208.82	217.29
Feed cost, $[e]	29.47	29.47	25.26
Total expense, $	245.84	238.29	242.55
Returns to capital, land, labor and management, $	-11.90	-.57	5.22

[ab]Means bearing different superscripts are significantly different ($P<.05$).

[c]Valued at 70¢/kg.

[d]Valued at 77¢/kg.

[e]Barley at 12.1¢/kg. Forage at $7.50 per steer month.

TABLE 8. PRODUCTION AND CARCASS CHARACTERISTICS FOR FINISHING PHASE, TRIAL 2[j]

	Irrigated Pasture		Range	Feedlot			
Item	AF	AO	CW	ARS	PRS	WS	GH
No. of steers	5	5	9	5	5	5	5
Initial wt, kg	337	341	355	381	384	387	393
Daily gain, kg	1.34[b]	1.33[b]	.84[a]	1.18[b]	1.05[ab]	1.00[ab]	1.03[ab]
Daily feed intake, kg[e]	5.20	5.20	5.45	7.95	7.69	7.14	9.07
Daily hay intake, kg	5.70	5.70					
Feed/gain ratio	8.13	8.20	6.49	6.60	7.29	7.14	8.80
Days on feed[f]	99	99	108	87	78	83	64
Carcass Characteristics							
24 hr carcass st, kg	252[a]	260[ac]	251[a]	291[bd]	280[bcd]	282[bcd]	276[ad]
Carcass grade[g]	7.6	9.4	9.0	10.6	9.4	9.4	10.0
Marbling score[h]	3.0	3.8	3.8	4.2	3.8	3.8	4.0
Rib eye area, cm	26.57	25.12[a]	24.84[a]	28.73[b]	29.85[b]	27.51	27.33
Fat color[i]	3.0[ab]	3.0[ab]	3.0[a]	3.4[b]	3.6[bc]	3.4[b]	4.0[bc]

[abcd]Means within a row bearing different superscripts are significantly different ($P<.05$).

[e]Feed intake only includes grain for the irrigated pasture and range treatments.

[f]Feedlot cattle went off feed for 30 days which is not accounted for.

[g]10 = medium good, 7 = medium standard.

[h]4 = slight, 3 = traces.

[i]4 = slight yellow tinge, 3 = slightly yellow.

[j]AF, AO, CW, ARS, PRS, WS and GH are alfalfa-fescue, alfalfa-orchardgrass, crested wheatgrass, annual rye grass straw, perrenial rye grass straw, wheat straw and grass hay treatments respectively.

TABLE 8. (continued)

Item	Irrigated Pasture		Range	Feedlot			
	AF	AO	CW	ARS	PRS	WS	GH
Taste panel evaluation[k]							
Aroma	5.93		5.90	5.34	5.42	5.56	5.36
Tenderness	4.61^{bd}		3.93^{a}	5.26^{bc}	4.48^{bd}	5.84^{bc}	4.68^{bd}
Juiciness	5.26		5.03	5.26	5.12	5.18	5.16
Flavor	5.68		5.53	5.64	5.44	5.60	5.34
Overall desirability	4.94^{b}		4.57^{c}	5.32^{b}	4.80^{ac}	5.06^{b}	5.10^{b}

[abcd]Means within a row bearing different superscripts are significantly different ($P<.05$).

[j]AF, AO, CW, ARS, PRS, WS and GH are alfalfa-fescue, alfalfa-orchardgrass, crested wheatgrass, annual rye grass straw, perrenial rye grass straw, wheat straw and grass hay treatments respectively.

[k]Scored on a scale of 1 to 8 with 8 being most desirable.

due primarily to the range beef being less tender ($P<.05$) than the other treatments. Tenderness scores of this beef were considerably less (3.93 vs 4.47) than that of trial 1.

Trial 3. Production and carcass data for fall calves are shown in table 9. Daily gains of steers on the IP-SB-CW treatment were less ($P<.05$) than the other four treatments. Total days on feed were considerably longer as would be expected on an all forage diet. No differences ($P<.05$) were detected among treatments for carcass weight, grade or marbling score. Rib eye areas of the CSM and DPW treatments were greater ($P<.05$). Fat color score of the IP-SB-CW treatment was less ($P<.05$) than the other treatments.

The steers on the IP-SB-CW treatment received less than .34 kg of barley daily. The steers in the other treatments consumed 4.54 kg or more of grain per day. Thus, the savings in grain alone amounted to 4.2 kg per day or enough to have finished 10 more steers. By utilizing the irrigated pasture before going to the feedlot the IP-CSM and the IP-DPW treatments required 40 days less to finish than the CSM or DPW treatments, a savings of 198 kg of grain.

The three studies presented in this paper show that a substantial savings of grain can be made utilizing forage finishing systems, particularly when compared to conventional finishing systems feeding 80% grain rations. Livestock and Meat Situation[1] reports that typical Great Plains custom feeders feed 1500 kg of grain to 272 kg steers for six months. The range and irrigated pasture systems reported in this study utilized 350 kg to finish 325 kg steers. This is a savings of 1150 kg of grain over the conventional finishing system.

Daily gains were greater on crested wheatgrass range as compared to irrigated pastures for the growing stage. Returns to land, labor, management and capital were also greatest for the range treatment.

Carcass grades fell in the high standard to good grade for all treatments. Brady (1957) found that the public prefers beef of U.S.D.A. good grade and would buy more of it, as compared to choice or prime

[1]Livestock and Meat Situation, Economic Research Service, U.S. Department of Agriculture, LMS-217, October 1977.

TABLE 9. PRODUCTION AND CARCASS DATA FOR FALL CALVES, TRIAL 3[j]

	Range[h]	Feedlot[i]			
Item	IP-SB-CW	CSM	DPW	IP-CSM	IP-DPW
No. of steers	10	5	5	5	5
Initial wt, kg	307.5	261.2	252.9	293.4	290.2
Daily gain, kg	.66[a]	.99[b]	.94[b]	.90[b]	.85[b]
Daily feed intake, kg	8.46	7.56	8.07	8.18	8.78
Feed/gain ratio	12.82	7.64	8.59	9.09	10.33
Days on feed	252	191	199	133	148
Carcass Characteristics					
24 hr carcass wt, kg	255	270	263	248	250
Carcass grade[e]	9.7	8.4	10.2	9.4	10.0
Marbling score[f]	3.9	3.6	4.4	3.8	4.0
Rib eye area, cm	9.03[a]	10.53[b]	10.67[b]	9.38[a]	10.23[b]
Fat color[g]	2.8[a]	4.6[bc]	4.2[b]	4.0[bd]	4.2[b]

[abcd]Means bearing different superscripts are significantly different ($P < .05$).

[e]10 = good, 7 = standard.

[f]4 = slight, 3 = traces.

[g]4 = slightly yellow tinge, 3 = slightly yellow, 4 = moderately yellow.

[h]Includes time from when steers were removed from irrigated pasture until they were slaughtered. Forage is not included in intake for the 60 days on crested wheatgrass.

[i]Includes time in feedlot after steers started on treatment.

[j]IP-SB-CW, CSM, DPW, IP-CSM, IP-DPW are irrigated pasture to feedlot at Squaw Butte to crested wheatgrass pasture, cottonseed meal, dried poultry waste, irrigated pasture to cottonseed meal ration in feedlot and irrigated pasture to dried poultry waste ration in feedlot treatment management schemes respectively.

grades, if it were available. Kidwell _et al_. (1959) found that carcass grade does not have a great deal of influence on taste and acceptance of meat. Acord (1977) stated that consumers will need to learn how to appreciate the advantages of meat that carries relatively little fat and, therefore, grades "Good" instead of "Choice". Overall desirability of the beef from the feedlot treatments was greater than the range or irrigated pasture treatments but all were acceptable. Schupp _et al_. (1976) reviewed research results from state experiment stations evaluating the acceptability of forage-finished and limited grain-finished beef and found forage-finished beef to be acceptable in each case.

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ECONOMIC ANALYSIS

ECONOMIC ANALYSIS OF ALTERNATIVES FOR FINISHING SLAUGHTER STEERS IN EASTERN OREGON[1]

Prior to 1972 a surplus of grain in the world provided sufficient feed for finishing cattle in the feedlot. During 1973 a world wide shortage of grain occurred causing many researchers to look at the feasibility and economics of finishing cattle on pasture. Rangelands having no better alternative use than for grazing have the greatest potential for this type of production. Ranchers currently utilizing our rangelands have traditionally followed a cow-calf system of production. The calves are sold to feedlots in nearby valleys which have feed grains available to grow and finish these cattle. With introduced grass species such as crested wheatgrass (Agropyron desertorum), the rangeland can produce three to five times as much as with native species. Average daily gains of 1.5 to 2 pounds have been made by yearling cattle with no supplement grazing on range (Raleigh, 1970). Where sufficient water is available irrigated pastures have also proven to be beneficial in increasing carrying capacity and producing maximum pounds of beef per acre.

Management opportunities may arise for the rangeland rancher due to a shortage of and/or human competition for grain, thus it may once again be more economical to finish cattle under a grazing system. It will be necessary for him to know more about the mangement and economics of production systems available for finishing beef. The objectives of this paper are (1) to compare alternative systems for growing out cattle utilizing maximum forage, (2) to compare alternatives for finishing cattle on pasture and (3) to compare two feedlot methods of finishing cattle utilizing 40% roughage rations. Due to the design and conductance of the studies, an inner comparison between finishing on pasture and in the feedlot will not be made.

Past and current research at the Squaw Butte Experiment Station has demonstrated that satisfactory gains can be made on irrigated pasture and crested wheatgrass range with carcasses produced which grade high-

[1]This paper is written for producers, thus English measures are used.

standard and good (Raleigh, 1970). Schupp et al. (1976) reported satisfactory acceptance of good grade beef.

MATERIALS AND METHODS

Sixty Hereford steers born the previous spring were assigned to a growing phase on May 11, 1976. The steers were stratified by weight and breed to crested wheatgrass range and alfalfa-fescue or clover-fescue irrigated pastures. Thirty-six were assigned to range and twelve to each irrigated pasture treatment. Steers on crested wheatgrass were moved to new range when approximately one-third of the forage had been grazed. Those on irrigated pasture were rotated between 2 two acre pastures to allow for irrigation and regrowth.

Table 1 gives the supplement schedule followed on crested wheatgrass range. The steers on irrigated pasture received 3.2 pounds of barley each day for an energy supplement. Supplement was fed to all steers at the same time each morning to help insure maximum grazing time. Wooden troughs constructed of 1/2 inch plywood, 2 feet wide and 8 feet long with 2 X 4's of sufficient length to make the lip of the trough, were used to feed the supplements to the steers. When it was noticed that some wastage was occurring due to cattle walking in the troughs, the troughs were raised 18 inches off the ground by using 2 X 4's for legs and bracing with 2 X 4's for additional strength.

The steers drank water free choice from metal tanks. Water was hauled to steers on range, a round trip of approximately eight miles. Salt and a 50:50 salt-bonemeal mix were offered to steers free choice. Copper sulfate was added to the salt at the rate of one-half pound copper sulfate to one hundred pounds of salt to prevent diarrhea on the irrigated pastures. The irrigated pastures have excess molybedenum which ties up the copper, thus additional copper is needed by the animal.

The steers were weighed every twenty-eight days to check weight gains. The growing period was eighty-five days long.

Following the growing period, five steers from each irrigated pasture treatment and 10 steers from the crested wheatgrass range were assigned to the feedlot treatment which was conducted at Oregon State University's facilities in Corvallis. Assignments were made by stratification of weight and breed. This left six steers in each irrigated pasture treatment and twenty-five in the range treatment for the finish-

TABLE 1. DAILY SUPPLEMENT INTAKE ON RANGE

Period	Biuret (lbs)	Barley (lbs)
5/11 - 6/15	.0	1
6/16 - 6/17	.03	1
6/18 - 6/19	.04	1
6/20 - 6/26	.05	1
6/27 - 7/3	.09	1
7/4 - 7/10	.10	1.3
7/11 - 7/17	.12	1.6
7/18 - 7/24	.14	1.8
7/25 - 8/3	.14	2.5

TABLE 2. FINISHING RATIONS FOR STEERS ON IRRIGATED PASTURE AND CRESTED WHEATGRASS

Ingredient	Crested Wheat	Irrigated Pasture
Rolled barley, lb	1938	1962
Biuret, lb	25	8
Salt, lb	15	19
Limestone, lb	21	10
Vitamin A premix[a]	1	1
Total	2000	2000
Ration cost ($/T)	121.00	119.35

[a]2 million IU/lb.

ing phase. Table 2 shows finishing rations fed steers on irrigated pasture and crested wheatgrass. The steers were brought up to fifteen pounds of grain by gradually increasing the amount fed by half-a-pound every other day. When they reached eight pounds per head per day the ration was fed twice daily. Again the times of feeding were the same each day in order to increase and encourage grazing. Steers in each of the irrigated pasture treatments and the range treatment grazed the forage available to them for the roughage part of their ration. The steers on irrigated pasture received baled meadow hay as their roughage the last 31 days due to frost stopping pasture growth. They were moved to another area and fed as one group to limit damage to the pastures from trampling. The range steers were finished on crested wheatgrass range.

The steers finished in the feedlot at Corvallis were fed one of two 40% roughage based rations (table 3). The ration was offered <u>ad libitum</u> and steers were slaughtered when they had three tenths inches of back fat as measured by ultrasonic techniques.

Fifty of the steers in this study were slaughtered at the slaughtering facility at the Oregon State University Campus in Corvallis. Carcass data was collected to further compare the three finishing systems.

RESULTS AND DISCUSSION

Growing Phase

Gain and consumption data for the 84 day growing phase are shown in table 4. The steers grazing crested wheatgrass pasture gained 3.23 pounds per day compared to 2.63 and 2.65 pounds per day for the steers grazing clover-fescue and alfalfa-fescue pastures respectively. The data shown in this table are the average values used in calculating the budget for the growing phase.

<u>Budget Calculation</u>. The figures in the budgets presented in this paper are not taken to be actual costs of this type of a system, but are there to illustrate cost considerations and calculations. Thus,

TABLE 3. FEEDLOT RATIONS FOR STEERS

Ingredient	Ration #1(lbs)	Ration #2(lbs)
Straw	750	750
Alfalfa	50	50
Molasses	150	150
Tallow	50	50
Barley, rolled	764	773
Cottonseed meal	225	---
Dried Poultry Waste	---	185
Feather meal	---	40
Limestone	9	---
Antibiotic (TM-10)	1	1
Vitamin A premix[a]	1	1
Total	2000	2000
Ration Cost ($/T)	90.00	80.00

[a]2 million IU/lb.

TABLE 4. GAIN AND CONSUMPTION DATA DURING 84 DAY GROWING PHASE

Item	Range	Clover-fescue	Alfalfa-fescue
No. of steers	36	12	12
Initial wt., lb	435	443	440
Final wt., lb	707	664	663
Daily supplement consumption, lb	1.30	3.33	3.33
Gain, lb	272	221	222
Daily gain, lb	3.23[a]	2.63[b]	2.65[b]

[ab]Means bearing different superscripts are significantly different ($P<.05$).

operators may utilize these budgets as a means of determining their management based on their known costs.

The growing phase budget is shown in table 5. The purchased value prices used were prices for good 400-500 pound steer calves at the North Portland market. For May of 1977 these prices were $37.00 per hundredweight. The sale value prices were also taken from the North Portland market for good 600-700 pound steers. For August of 1977 the average value was $34.00 per hundredweight. The selling cost of $3.35 includes yardage and commission fees at a terminal market. Feed costs were based on rolled barley at $121 per ton. The interest on capital was calculated over the period of ownership of the cattle for the cattle cost plus feed cost at an annual rate of nine percent. Transportation charges included trucking to range for the crested wheat treatment, cost of a vehicle for feeding and checking valued at 17¢ per mile and the cost for shipping to market calculated at $2.31 per hundred miles per head for an average of 225 miles. Labor was figured at $3.00 per hour. Each group required one hour per day for feeding. The value of the grass was calculated at $7.50 per AUM (yearling month) for the three month period.

The cost of irrigation (water, electricity, machinery) was not included for the irrigated pastures. The cost of pasture improvement was also omitted due to the variability that exist in the cost of improvement practices.

Budget Results. The net return to management was greatest for the crested wheatgrass steers at $25.50 per head. Both groups of steers on irrigated pasture showed a deficit return to management of $3.21 and $2.40 per head for the clover-fescue and the alfalfa-fescue irrigated pasture treatments respectively. Thus, in order to break even with the costs and prices included here the irrigated pasture steers would have to sell for almost $4.50 per hundredweight more than for what they sold.

Finishing Phase

Results and Discussion. The production and carcass characteristics for the finishing phase are shown in table 6. The initial weights of the feedlot steers are greater due to a pre-conditioning period at the

TABLE 5. BUDGET FOR THE GROWING PERIOD

Item	Crested wheat	Irrigated Pasture: Clover-fescue	Irrigated Pasture: Alfalfa-fescue
Sale value	240.38	225.76	225.42
Expenses			
Selling cost	3.35	3.35	3.35
Purchase value	160.95	163.91	162.80
Feed cost	6.61	16.92	16.92
Variable cost			
Interest on capital	3.77	4.07	4.04
Vet and medical	---	---	---
Death loss (½%)	.80	.82	.81
Transportation	9.90	6.90	6.90
Expenses sub-total	185.38	195.97	194.82
Return/hd to grass, labor & management	55.00	29.79	30.60
Less labor	7.00	10.50	10.50
Return/hd to grass & management	48.00	19.29	20.10
Less grass	22.50	22.50	22.50
Return to management	25.50	-3.21	-2.40
Breakeven selling price/cwt	30.00	34.48	34.36
Selling price/cwt	34.00	34.00	34.00
Net margin/cwt	+4.00	-.48	-.36

TABLE 6. PRODUCTION AND CARCASS CHARACTERISTICS FOR FINISHING PHASE

	Irrigated Pasture		Range	Feedlot	
Item	Alfalfa-fescue	Clover fescue	Crested wheatgrass	CSM	DPW
No. of steers	6	6	25	10	10
Initial wt., lbs	662	664	706	827	825
Final wt., lbs	945	964	976	1087	1117
Daily gain, lbs	2.99[a]	2.97[a]	2.55[ab]	2.00[c]	2.24[bc]
Daily intake, lbs[1]	11.24	11.24	12.03	19.95	23.25
Feed/gain ratio	3.76	3.78	4.72	9.98	10.38
Hay consumption, lb	152	152	---	---	---
Days on feed	103	103	103	130	130
Carcass wt., lbs	519[a]	524[ac]	557[ab]	609[b]	626[b]
Carcass grade, avg.[2]	S[a]	S[ac]	G-[ab]	G[b]	G[bc]

[abc]Means bearing different superscripts are significantly different ($P<.05$).

[1]Feed intake does not include forage consumption for irrigated pasture or range.

[2]S = medium standard, G = medium good, G- = low good.

feedlot before going onto the experimental study. Gains of steers on irrigated pasture were greater than the other treatments with the two feedlot treatments gaining the least. However, it was possible for the cattle in the feedlot to be fed an additional 27 days on the average thus they had the greatest carcass weight. The feedlot carcasses graded average good while those on crested wheatgrass and irrigated pasture graded low good and standard respectively.

Budget Calculation. The finishing phase budget for the irrigated pasture and range steers is shown in table 7. The sale value shown reflects the grade and weight of the average carcass. Due to a lack of marketing information for carcasses of lower quality grades, the prices were calculated based on actual receipts of similar cattle sold directly to a slaughter plant which paid by carcass weight and grade. Carcasses of good grade brought $62.50 per hundredweight regardless of size and standard carcasses brought $51.00 per hundred weight. Calculating back to a liveweight basis the standard grade cattle sold for $28.00 per hundred weight and the good grade sold for $35.00 per hundred weight. The higher dressing percent of the low good steers from crested wheat made their liveweight price $35.50 per hundred weight.

The purchase value was calculated at $35.00 per hundred weight based on the North Portland market. Feed prices shown in tables 2 and 3 were used to calculate the cost. Interest was computed as before except over a six month time period. Veterinary and medical cost are lower than one might expect to have due to the known backgrounding program of these cattle. Death loss was calculated at one-half of one percent based on purchase value. Transportation was calculated as before. Labor for the treatments was calculated at $3.00 per hour. The charge for grass was $7.50 AUM made at the rate of .25 AUM per steer month. This was reduced due to lower forage intake as a result of the increased grain consumption.

The price situation for this time period was not condusive to feeding cattle as reflected in the negative net margins for all treatments. The crested wheatgrass treatment minimized losses and had the closest net margin. Thus, under a different marketing situation where good grade cattle were bringing $40.00/cwt the cattle on crested wheat would

TABLE 7. BUDGET FOR THE FINISHING PERIOD ON RANGE AND IRRIGATED PASTURE

Item	Range	Irrigated Pasture	
	Crested wheatgrass	Clover-fescue	Alfalfa-fescue
Sale value, $	348.13	267.04	264.79
Expenses			
Selling cost, $	3.35	3.35	3.35
Purchase value, $	247.10	221.20	216.65
Feed cost, $	74.96	89.57	89.57
Variable costs			
Int. on capital, $	14.49	13.98	13.78
Vet & medical, $	.32	.32	.32
Death loss (½%), $	1.24	1.11	1.08
Transportation, $	9.90	6.90	6.90
Yardage, $	---	4.40	4.40
Expenses sub-total, $	351.36	340.83	336.05
Return/hd to grass labor & management, $	-3.23	-73.79	-71.26
Less labor, $	12.36	12.88	12.88
Return/hd to grass & management, $	-15.59	-86.67	-84.14
Less grass, $	9.38	9.38	9.38
Return to management, $	-24.97	-96.05	-93.52
Breakeven selling price/cwt, $	38.23	37.66	37.92
Selling price/cwt, $	35.50	28.00	28.00
Net margin/cwt, $	-2.73	-9.66	-9.92

show a favorable return to management of $17.30/head.

The finishing phase budget for the feedlot treatments is shown in table 8. The budget was calculated in the same manner as the irrigated pasture and crested wheatgrass treatments except that transportation to the feedlot was the only transportation charged as feedlots are often near slaughter facilities. Yardage and labor for feedlot were based on average costs published in Livestock and Meat Situation. The feedlot steers in the DPW treatment were produced at a lower cost.

SUMMARY

Production data presented in this study demonstrate the efficiency of gain possible on crested wheatgrass and irrigated pasture. The budget for the growing period shows a $4.00 net margin for the crested wheatgrass steers. During this study the growing phase was the most profitable and the greatest return to management would be realized if all cattle had been marketed at this point.

The cattle continued to gain satisfactorily during the finishing phase at two to three pounds per day. However, due to the lower quality carcass the prices received for these cattle was harshly penalized. Thus, negative net margins resulted due to the lower value of the product as compared to choice beef.

With the existing potential to produce market weight animals off of improved pastures in Eastern Oregon,the cattleman now can consider retaining ownership of his calves for future marketing. If the calves are fed at a rate through the winter such that gains will cover feed costs, the operator can evaluate his grass and market situation in the spring to determine if growing these steers out looks advantageous. Again in early August the operator can evaluate market prices to determine if finishing is practical. The information presented here will aid an operator in preparing budgets based on his own costs of production. For ranchers having access to improved range,this type of a production and management scheme can increase the number of marketing alternatives available.

TABLE 8. FEEDLOT BUDGET

Item	Feedlot CSM	Feedlot DPW
Sale value, $	380.60	391.33
Expenses		
Selling cost, $	3.35	3.35
Purchase value, $	289.45	288.75
Feed cost, $	120.75	116.75
Variable costs		
Int. on capital, $	16.30	16.05
Vet & medical, $	1.00	1.00
Death loss (½%), $	1.45	1.44
Transportation, $	5.20	5.20
Yardage, $	15.00	15.00
Expenses sub-total, $	452.50	447.54
Return/hd to grass labor & management, $	-71.90	-56.21
Less labor, $	9.56	9.56
Return/hd to grass & management, $	-81.46	-65.77
Less grass, $	---	---
Return to management, $	-81.46	-65.77
Breakeven selling price/cwt, $	42.51	40.92
Selling price/cwt, $	35.00	35.00
Net margin/cwt, $	-7.51	-5.92

OVERALL SUMMARY

OVERALL SUMMARY

The chromic oxide (Cr_2O_3) technique was used to determine individual fecal output of six 208 kg steers fed five different ratios of barley to hay. Total daily fecal output derived from grab samples collected at 0700, 1200, 1700 and composite samples were correlated to actual daily fecal output. Respective correlation coefficients were .63, .59, .80, and .79. The average recovery of Cr_2O_3 for the entire study was $94.05 \pm 3.91\%$. Estimates of forage intake using lignin (L), crude fiber (CF), nitrogen (N) and indigestible dry matter (IDM) were correlated to actual forage consumption with the respective coefficients (r) of .92, .93, .96 and .89. No significant differences were found between collection times of 0700, 1200, 1700 and the composite sample for L, CF or N estimates of forage consumption. Estimates of forage consumption were most accurately predicted by the L and CF methods. Use of these indicators in a grazing situation indicated that these methods did not predict forage intake accurately (see appendix C).

Three trials were conducted using a total of 129 Hereford or Hereford X Angus steers. Trials 1 and 2 evaluated the performance of steers on irrigated pasture and crested wheatgrass during the growing phase. The steers were allotted to various finishing regimes from the growing study. These included finishing on irrigated pasture, on range and in the feedlot using two 40% roughage based rations for trial 1 and four 40% roughage based rations in trial 2. Trial 3 was conducted using fall born steers which were either immediately sent to the feedlot and fed two 38% straw based rations, put on irrigated pasture prior to going to the feedlot or grazed on irrigated pasture, wintered on a 100% forage diet of 2/3 alfalfa and 1/3 grass hay and then finished on crested wheatgrass range the following spring.

Steers gained faster ($P<.05$) on range than on either the alfalfa-fescue or clover-fescue irrigated pastures of trial 1 and 2. Steers finished on irrigated pasture and range made greater daily gains than the steers receiving the 40% roughage rations in the feedlot of trial 1. In trial 2 the feedlot steers gained faster with the range steers gaining the least ($P<.05$). In both trials 1 and 2 the feedlot groups had greater ($P<.05$) 24 hr carcass weights due to a longer feeding period. Carcass grades were lowest for the alfalfa-fescue irrigated pasture group in both trials. Overall desirability of the beef was greatest for the feedlot groups in both trials.

Daily gains were lowest ($P<.05$) for the fall born steers finished on crested wheatgrass (trial 3). Carcass weight, grade and marbling scores were not significantly different between treatments. Less than 86 kg of barley was used to produce slaughter weight steers from crested wheatgrass range under the management of trial 3.

Economic analysis of the treatments utilized in the growing phase indicated greater returns to capital, land, labor and management for steers on the crested wheatgrass range. Budgets were developed which would help an operator determine the profitability of growing and finishing cattle under grazing conditions. Examples were utilized from the results of trial 1 to illustrate calculations for budget items.

The results of this study demonstrate the possible marketing alternatives available to a producer who has access to good rangeland with a carrying capacity of 1.2 to 2 hectares per steer month. Producers with this type of rangeland have four marketing options: (1) selling weaned calves in late fall, (2) wintering the calves to make economic gains and sell in the spring as light feeders, (3) turn the yearlings out to range and sell as heavy feeders in mid-summer or (4) finish on pasture utilizing a grain diet.

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APPENDICES

APPENDIX A

INDIVIDUAL ANIMAL PRODUCTION AND CARCASS DATA

KEY FOR APPENDIX A.

Treatment: When two treatments are given such as CW-CSM in the table, the first represents the growing phase and the latter the finishing phase.

CW = crested wheatgrass	ARS = annual rye grass straw
CSM = cottonseed meal	PRS = perennial rye grass straw
DPW = dried poultry waste	WS = wheat straw
AF = alfalfa-fescue	GH = grass hay
CF = clover fescue	IP = irrigated pasture
AO = alfalfa-orchard grass	SB = Squaw Butte feedlot

Production: ADG = average daily gain.

Carcass Measurements: Descriptive terms and numerical values.

Marbling score:	3 = traces, 4 = slight, 5 = small.
Marbling texture:	3 = slightly coarse, 4 = slightly fine, 5 = moderately fine, 6 = fine, 7 = very fine.
Texture of lean:	3 = slightly coarse, 4 = slightly fine, 5 = moderately fine, 6 = fine, 7 = very fine.
Firmness of lean:	5 = moderately firm, 6 = firm, 7 = very firm.
Lean color:	3 = dark red, 4 = moderately dark red, 5 = slightly dark red, 6 = cherry red, 7 = very light cherry red.
Fat color:	2 = moderately yellow, 3 = slightly yellow, 4 = slightly yellow tinge, 5 = white.

Quality Grades:	High	Average	Low
Prime (P)	17	16	15
Choice (C)	14	13	12
Good (G)	11	10	9
Standard (S)	8	7	6

TABLE 1. PRODUCTION AND CARCASS DATA FOR TRIAL 1, 1976.

I.D. No.	W9	W21	021	029	B18	B19	Y2	Y14	Y34	W2
Treatment	CW	CW	CW	CW	CW	CW	CW	CW	CW	CW
Beginning wt. (lb)	550	478	388	480	362	416	348	450	406	430
End growing phase wt. (lb)	880	800	650	750	625	705	580	735	690	710
Finished wt. (lb)	1200	1010	865	1015	910	930	845	1045	1010	1000
ADG growing phase (lb)	3.98	3.88	3.16	3.25	3.17	3.48	2.80	3.43	3.42	3.37
No. days finishing	96	96	96	96	110	110	96	96	110	110
ADG finishing phase (lb)	3.33	1.42	2.06	2.76	2.59	2.04	2.45	3.23	2.91	2.64
Hot carcass wt. (lb)	659			564	511	520		590	550	562
24 hr. carcass wt. (lb)	651			558	500	510		581	541	552
% kid fat	2.0			2.0	1.5	2		2	1.5	2.0
Marbling score	4			4	4	4		4	3	5
Marbling texture	6			6	2	5		4	4	6
Texture of lean	7			5	7	6		4	6	6
Firmness of lean	7			5	7	6		6	7	7
Lean color	7			7	7	6		6	7	6
Fat color	3			4	3	4		4	4	4
Adjusted fat thickness	.50			.40	.35	.40		.35	.30	.50
Loin eye area	10.72			10.04	8.20	8.39		10.73	9.30	9.46
Grade	G(10)			G(10)	G(10)	G(10)		G(10)	S(7)	C(13)

TABLE 1. (continued)

I.D. No.	W29	04	034	B4	B13	B32	Y35	Y47	W23	W32
Treatment	CW	CW	CW	CW	CW	CW	CW	CW	CW	CW
Beginning wt. (lb)	502	566	398	422	412	336	416	452	376	496
End growing phase wt. (lb)	795	795	665	690	700	605	670	740	645	800
Finished wt. (lb)	985	1095	975	1010	1025	815	965	955	915	1085
ADG growing phase (lb)	3.53	2.76	3.22	3.23	3.47	3.24	3.06	3.47	3.24	3.66
No. days finishing	110	96	110	96	96	96	110	110	110	96
ADG finishing phase (lb)	1.98	3.13	2.82	3.33	3.39	1.61	2.68	1.95	2.45	2.97
Hot carcass wt. (lb)	538	587	541	537	547		549	528	507	604
24 hr. carcass wt. (lb)	532	581	531	531	542		539	519	499	5.97
% kid fat	2.0	2.5	2.0	2.0	1.5		1.5	2.0	1.5	2.0
Marbling score	4	4	3	4	4		3	3	3	4
Marbling texture	4	5	2	5	4		4	1	4	4
Texture of lean	5	6	3	6	5		6	6	6	6
Firmness of lean	7	7	6	7	6		7	6	6	7
Lean color	4	4	5	5	6		6	6	6	5
Fat color	3	3	4	3	3		3	4	4	3
Adjusted fat thickness	.25	.45	.17	.30	.30		.25	.40	.25	.40
Loin eye area	8.43	9.36	9.86	10.50	10.14		10.37	8.46	7.72	10.55
Grade	G(10)	G(10)	S(7)	G(10)	G(10)		S(7)	S(7)	S(7)	G(10)

TABLE 1. (continued)

I.D. No.	03	019	B26	B33	Y4*	Y38	W6	W13	010
Treatment	CW	CW	CW	CW	CW	CW	CW-CSM	CW-CSM	CW-CSM
Beginning wt. (lb)	500	382	344	494	386	448	430	542	430
End growing phase wt. (lb)	740	625	580	785	665	730	650	855	720
Finished wt. (lb)	985	885	825	1020		1040	1035	1075	1125
ADG growing phase (lb)	2.89	2.93	2.84	3.51	3.36	3.40	2.65	3.77	3.49
No. days finishing	110	110	96	96		96	192	90	139
ADG finishing phase (lb)	2.01	2.36	1.92	2.45		3.23	1.40	.74	2.01
Hot carcass wt. (lb)	564	491		588		586	591	612	637
24 hr. carcass wt. (lb)	555	483		581		580	580	602	630
% kid fat	2.0	1.5		2.0		1.5	2.5	2.0	1.5
Marbling score	4	4		3		4	5	2	4
Marbling texture	4	3		5		5	5	6	6
Texture of lean	4	7		5		6	6	6	5
Firmness of lean	7	6		6		7	7	7	7
Lean color	6	7		5		6	5	6	5
Fat color	4	4		3		3	3	4	4
Adjusted fat thickness	.50	.30		.35		.45	.50	.35	.45
Loin eye area	9.74	8.46		10.47		10.25	10.35	12.56	11.83
Grade	G(10)	G(10)		S(7)		G(10)	C-(12)	S-(6)	G(10)

*Y4 died 9/3/76.

TABLE 1. (continued)

I.D. No.	Y3	Y6	W30	020	033	B22	B27
Treatment	CW-CSM	CW-CSM	CW-DPW	CW-DPW	CW-DPW	CW-DPW	CW-DPW
Beginning wt. (lb)	380	378	506	516	460	354	418
End growing phase wt. (lb)	630	690	750	795	735	595	690
Finished wt. (lb)	1089	1066	1041	1100	1160	1071	1153
ADG growing phase (lb)	3.01	3.76	2.94	3.36	3.31	2.90	3.28
No. days finishing	150	102	81	81	102	157	139
ADG finishing phase (lb)	2.27	2.22	2.27	2.23	2.63	2.06	2.71
Hot carcass wt. (lb)	621	608	593	626	665	612	649
24 hr. carcass wt. (lb)	610	597	583	616	650	600	646
% kid fat	2.5	3.0	1.5	1.5	2.0	3.0	2.5
Marbling score	5	4	3	4	4	5	4
Marbling texture	5	4	5	4	5	5	5
Texture of lean	6	4	5	4	6	7	6
Firmness of lean	7	6	5	6	6	7	6
Lean color	6	6	6	6	7	6	6
Fat color	4	4	5	4	5	5	4
Adjusted fat thickness	.70	.40	.45	.35	.50	.70	.50
Loin eye area	9.92	9.85	10.46	10.73	10.15	9.08	11.25
Grade	C-(12)	G+(11)	S(7)	G(10)	G(10)	C-(12)	G(10)

TABLE 1. (continued)

I.D.No.	W1	W34	O15	B10*	B31	Y26	Y48	W12	O5
Treatment	AF	AF	AF	AF	AF	AF	AF	AF-CSM	AF-CSM
Beginning wt. (lb)	508	490	370	440	354	510	372	458	536
End growing phase wt. (lb)	689	707	555	671	553	721	578	691	739
Finished wt. (lb)	972	1014	836		8.92	1096	862	1180	1144
ADG growing phase (lb)	2.15	2.58	2.20	2.75	2.37	2.51	2.45	2.77	2.42
No. days finishing	102	102	102		102	102	102	102	102
ADG finishing phase (lb)	2.75	2.98	2.50		3.29	3.64	2.76	2.72	2.29
Hot carcass wt. (lb)	528	561			476	586	439	673	653
24 hr. carcass wt. (lb)	525	557			472	579	435	661	641
% kid fat	2.0	2.0			2.0	1.5	1.5	3.0	2.0
Marbling score	3	3			3	3	4	5	4
Marbling texture	4	4			3	3	4	5	4
Texture of lean	5	5			6	4	5	6	6
Firmness of lean	6	5			6	6	7	6	5
Lean color	4	5			5	6	5	6	6
Fat color	2	2			2	3	4	4	4
Adjusted fat thickness	.25	.35			.25	.34	.30	.50	.50
Loin eye area	9.60	10.79			9.28	10.26	8.41	10.05	10.55
Grade	S(7)	S(7)			S(7)	S(7)	G(10)	C-(12)	G(10)

*B10 died 9/1/76

TABLE 1. (continued)

I.D. No.	016	B17	Y18	W31	06*	09	B5	Y5	Y40
Treatment	AF-CSM	AF-CSM	AF-CSM	CF	CF	CF	CF	CF	CF
Beginning wt. (lb)	474	352	416	416	390	508	432	380	520
End growing phase wt. (lb)	669	546	616	647	613	759	650	581	723
Finished wt. (lb)	1082	1044	1032	912		1114	1002	892	1006
ADG growing phase (lb)	2.32	2.31	2.38	2.75	2.65	2.99	2.59	2.39	2.42
No. days finishing	102	157	164	102		102	102	102	102
ADG finishing phase (lb)	2.33	2.23	1.77	2.57		3.45	3.42	3.02	2.75
Hot carcass wt. (lb)	621	596	587	491		618	530	447	533
24 hr. carcass wt. (lb)	606	585	578	487		613	525	444	528
% kid fat	2.5	3.5	2.5	2.0		1.5	1.5	1.5	1.5
Marbling score	4	4	4	4		3	3	4	3
Marbling texture	4	7	4	3		3	6	5	4
Texture of lean	5	7	5	3		4	7	5	3
Firmness of lean	6	6	7	7		6	5	6	6
Lean color	6	6	6	3		3	5	6	3
Fat color	5	4	4	3		2	2	2	3
Adjusted fat thickness	.45	.60	.45	.30		.25	.25	.30	.10
Loin eye area	10.04	8.73	9.13	8.85		12.50	10.15	9.13	12.12
Grade	G(10)	G-(9)	G+(11)	G(10)		S(7)	S(7)	G(10)	S(7)

*06 died 9/2/76.

TABLE 1. (continued)

I.D. No.	Y42	W5	W15	O8	B14	Y41
Treatment	CF	CF-DPW	CF-DPW	CF-DPW	CF-DPW	CF-DPW
Beginning wt. (lb)	336	504	506	428	396	396
End growing phase wt. (lb)	554	673	723	626	585	577
Finished wt. (lb)	858	1142	1169	1121	1087	1133
ADG growing phase (lb)	2.60	2.01	2.58	2.36	2.25	2.15
No. days finishing	102	164	102	157	150	164
ADG finishing phase (lb)	2.63	1.77	2.13	2.33	2.06	2.30
Hot carcass wt. (lb)		648	667	638	621	643
24 hr. carcass wt. (lb)		640	655	628	609	635
% kid fat		2.5	3.0	3.0	2.0	3.0
Marbling score		4	5	5	4	3
Marbling texture		5	5	6	6	6
Texture of lean		6	6	5	7	5
Firmness of lean		7	6	6	7	6
Lean color		6	6	5	6	6
Fat color		4	4	5	4	4
Adjusted fat thickness		.40	.50	.50	.35	.45
Loin eye area		9.47	10.05	10.80	10.47	10.35
Grade		G-(9)	C-(12)	C-(12)	G+(11)	S+(8)

TABLE 2. PRODUCTION AND CARCASS DATA FOR TRIAL 2, 1977.

I.D. No.	Y1	Y12	Y48	Y26	Y28	Y33	Y34	Y35	Y38
Treatment	CW	CW	CW	CW	CW	CW	CW	CW	CW
Beginning wt. (lb)	804	594	576	674	622	610	644	600	544
End growing phase wt. (lb)	910	780	695	835	800	745	810	750	710
Beg. wt. finishing (lb)									
Finished wt. (lb)	1130	960	880	1065	1000	940	1020	945	885
ADG growing phase (lb)	1.36	2.38	1.53	2.06	2.28	1.73	2.13	1.92	2.13
No. days finishing	108	108	108	108	108	108	108	108	108
ADG finishing phase (lb)	2.04	1.67	1.71	2.13	1.85	1.81	1.94	1.81	1.62
Hot carcass wt. (lb)	661	568	515	606	577	538	598	540	502
24 hr. carcass wt. (lb)	646	554	503	592	563	526	583	528	491
% kid fat	2.5	2.5	1.5	2.5	2.0	1.5	2.0	2.0	1.5
Marbling score	4	3	3	6	3	3	4	4	4
Marbling texture	5	4	4	6	4	5	4	4	2
Texture of lean	6	4	3	6	4	4	5	5	5
Firmness of lean	5	5	5	6	6	6	4	5	6
Lean color	5	5	6	6	6	5	5	6	5
Fat color	3	3	3	3	3	3	3	3	3
Adjusted fat thickness	.30	.23	.17	.40	.25	.37	.30	.25	.30
Loin eye area	9.60	10.80	9.20	9.30	9.75	9.36	11.24	10.03	8.70
Grade	G(10)	S(7)	S(7)	C(13)	S(7)	S(7)	G(10)	G(10)	G(10)

TABLE 2. (continued)

I.D. No.	03	06	09	019	024	W1	W20	W23	W26
Treatment	AF	AF	AF	AF	AF	AO	AO	AO	AO
Beginning wt. (lb)	798	560	568	602	634	612	650	548	662
End growing phase wt. (lb)	882	666	682	734	748	754	792	688	814
Beg. wt. finishing (lb)									
Finished wt. (lb)	1172	942	984	1026	1044	1035	1074	962	1116
ADG growing phase (lb)	1.11	1.39	1.50	1.74	1.50	1.87	1.87	1.84	2.00
No. days finishing	99	99	99	99	99	99	99	99	99
ADG finishing phase (lb)	2.93	2.79	3.05	2.95	2.99	2.84	2.85	2.77	3.05
Hot carcass wt. (lb)	634	528	543	565	556	596	611	539	630
24 hr. carcass wt. (lb)	619	529	530	551	543	583	604	525	618
% kid fat	2.5	1.5	2.5	2.0	2.5	3.0	2.5	2.5	3.0
Marbling score	3	3	3	4	2	4	4	3	4
Marbling texture	4	4	4	4	8	4	5	6	3
Texture of lean	4	6	4	4	5	5	5	5	3
Firmness of lean	4	5	5	6	1	6	6	6	6
Lean color	4	5	5	5	3	5	4	6	6
Fat color	3	3	3	3	3	3	3	3	3
Adjusted fat thickness	.13	.15	.23	.20	.15	.30	.30	.25	.40
Loin eye area	11.65	10.05	10.49	10.01	10.08	9.53	9.53	10.30	10.10
Grade	S(7)	S(7)	S(7)	G(10)	S(7)	G(10)	G(10)	S(7)	G(10)

TABLE 2. (continued)

I.D. No.	W31	04	Y14	W24	Y43	023	034
Treatment	AO	AF-ARS	CW-ARS	AO-ARS	CW-ARS	AF-ARS	AF-PRS
Beginning wt. (lb)	580	674	604	554	642	536	612
End growing phase wt. (lb)	712	822	800	708	775	644	736
Beg. wt. finishing (lb)		962	920	768	792	756	880
Finished wt. (lb)	1020	1230	1224	1128	1136	1010	1114
ADG growing phase (lb)	1.74	1.95	2.51	2.03	1.71	1.42	1.63
No. days finishing	99	72	86	101	86	86	86
ADG finishing phase (lb)	3.11	3.72	3.53	3.56	4.00	2.95	2.72
Hot carcass wt. (lb)	547	723	692	637	658	572	670
24 hr. carcass wt. (lb)	534	702	678	623	642	558	648
% kid fat	2.5	2.5	2.0	2.5	2.0	2.5	2.5
Marbling score	4	4	5	4	4	4	4
Marbling texture	4	4	5	6	6	5	5
Texture of lean	4	5	6	6	5	4	4
Firmness of lean	6	5	6	4	5	7	2
Lean color	5	6	6	5	5	6	5
Fat color	3	4	3	4	3	3	3
Adjusted fat thickness	.25	.25	.40	.30	.40	.35	.40
Loin eye area	10.00	12.98	10.33	10.37	12.32	10.53	12.45
Grade	G(10)	G(10)	C(13)	G(10)	G(10)	G(10)	G(10)

TABLE 2. (continued)

I.D. No.	W32	W4	Y40	Y16	Y5	W29	W19	Y17	O28
Treatment	AO-PRS	AO-PRS	CW-PRS	CW-PRS	CW-WS	AO-WS	AO-WS	CW-WS	AF-WS
Beginning wt. (lb)	536	634	572	654	626	534	650	606	590
End growing phase wt. (lb)	696	776	720	840	800	666	824	770	714
Beg. wt. finishing (lb)	790	884	748	928	844	780	982	824	830
Finished wt. (lb)	1030	1120	1000	1140	1048	1020	1188	1110	1078
ADG growing phase (lb)	2.11	1.87	1.90	2.38	2.23	1.74	2.29	2.10	1.63
No. days finishing	72	93	61	72	72	86	61	101	93
ADG finishing phase (lb)	3.33	2.54	4.13	2.94	2.83	2.79	3.38	2.83	2.67
Hot carcass wt. (lb)	582	676	569	682	596	621	683	650	646
24 hr. carcass wt. (lb)	564	662	540	668	579	607	649	646	630
% kid fat	2.0	2.0	1.5	3.0	2.0	2.0	2.5	2.5	2.0
Marbling score	3	4	4	4	4	4	3	4	4
Marbling texture	5	5	5	5	4	4	4	5	5
Texture of lean	4	4	4	5	5	5	7	5	5
Firmness of lean	5	4	7	5	6	5	6	5	5
Lean color	6	5	4	5	6	5	4	5	5
Fat color	4	3	4	4	4	3	4	3	3
Adjusted fat thickness	.40	.30	.30	.35	.25	.40	.45	.30	.30
Loin eye area	10.17	13.30	10.74	12.10	8.80	11.51	11.30	11.65	10.90
Grade	S(7)	G(10)	G(10)	G(10)	G(10)	G(10)	S(7)	G(10)	G(10)

TABLE 2. (continued)

I.D. No.	O17	Y19	W11	Y9	Y21
Treatment	AF-GH	CW-GH	AO-GH	CW-GH	CW-GH
Beginning wt. (lb)	608	546	604	560	698
End growing phase wt. (lb)	718	710	792	755	820
Beg. wt. finishing (lb)	824	856	818	880	954
Finished wt. (lb)	1046	1134	990	1034	1138
ADG growing phase (lb)	1.45	2.10	2.47	2.50	1.56
No. days finishing	72	72	61	51	61
ADG finishing phase (lb)	1.69	3.86	2.82	3.02	3.02
Hot carcass wt. (lb)	634	660	586	590	660
24 hr. carcass wt. (lb)	616	641	560	577	646
% kid fat	2.0	2.5	1.5	2.5	2.5
Marbling score	4	4	4	4	4
Marbling texture	4	4	6	5	4
Texture of lean	6	4	6	4	5
Firmness of lean	6	4	6	4	6
Lean color	5	6	4	6	4
Fat color	4	4	4	4	4
Adjusted fat thickness	.40	.30	.30	.20	.40
Loin eye area	10.11	11.99	10.70	10.04	10.96
Grade	G(10)	G(10)	G(10)	G(10)	G(10)

TABLE 3. PRODUCTION AND CARCASS DATA FOR FALL CALVES, 1976-1977.

I.D. No.	B3	B4	B5	B6	B11	B13A	B18
Treatment	IP-SB-CW	IP-SB-CW	IP-SB-CW	IP-SB-CW	IP-SB-CW	IP-SB-CW	IP-SB-CW
Weaning wt. (lb)	595	510	535	460	470	540	470
Wt. off IP (lb)	742	676	676	652	632	700	602
Beginning test wt. (lb)	740	665	715	640	630	700	630
Wt. out of feedlot (lb)	1050	915	1015	895	875	955	915
Slaughter wt. (lb)	1140	975	1115	990	960	1050	1030
No. days finishing	252	252	252	252	252	252	252
ADG finishing phase (lb)	1.59	1.23	1.59	1.39	1.31	1.39	1.59
Hot carcass wt. (lb)	603	528	621	545	512	609	565
24 hr. carcass wt. (lb)	588	514	606	536	499	594	552
% kid fat	1.5	1.5	3.0	2.5	2.5	2.5	1.5
Marbling score	3	3	6	4	3	5	4
Marbling texture	6	4	5	6	5	4	3
Texture of lean	2	8	7	7	7	4	7
Firmness of lean	4	6	7	4	5	6	7
Lean color	4	4	6	7	5	5	6
Fat color	3	3	2	3	3	2	3
Adjusted fat thickness	.10	.17	.30	.15	.25	.30	.22
Loin eye area	9.30	7.73	7.78	10.82	9.83	8.80	8.46
Grade	S(7)	S(7)	C(13)	G(10)	S(7)	C(13)	G(10)

TABLE 3. (continued)

I.D. No.	B19A	B23	B25A	B5	G5	O5	W5	Y5A
Treatment	IP-SB-CW	IP-SB-CW	IP-SB-CW	CSM	CSM	CSM	CSM	CSM
Weaning wt. (lb)	555	490	500	500	560	540	515	480
Wt. off IP (lb)	756	616	668					
Beginning test wt. (lb)	755	640	650	554	590	620	564	546
Wt. out of feedlot (lb)	1050	880	910					
Slaughter wt. (lb)	1135	995	1015	1074	1010	1052	1004	1060
No. days finishing	252	252	252	199	199	178	199	178
ADG finishing phase (lb)	1.51	1.41	1.45	2.33	1.79	2.15	2.07	2.57
Hot carcass wt. (lb)	665	535	572	620	583	610	591	615
24 hr. carcass wt. (lb)	649	521	558	611	568	602	586	603
% kid fat	3.0	2.0	2.5	3.0	3.0	2.5	3.5	3.0
Marbling score	4	2	5	4	3	4	4	3
Marbling texture	6	7	6	5	5	6	6	6
Texture of lean	6	6	6	5	6	6	6	4
Firmness of lean	6	5	7	5	5	7	6	4
Lean color	5	4	6	6	6	6	5	7
Fat color	3	3	3	5	5	5	4	4
Adjusted fat thickness	.25	.25	.45	.40	.30	.40	.32	.50
Loin eye area	10.98	8.15	8.40	11.50	9.34	10.97	10.61	10.22
Grade	G(10)	S(7)	C(13)	G-(9)	S(7)	G-(9)	G-(9)	S+(8)

TABLE 3. (continued)

I.D. No.	B6	G6	O6	W6A	Y6	B7	G7	O7	W7
Treatment	DPW	DPW	DPW	DPW	DPW	IP-CSM	IP-CSM	IP-CSM	IP-CSM
Weaning wt. (lb)	460	550	480	470	500	450	500	555	465
Wt. off IP (lb)						598	572	614	526
Beginning test wt. (lb)	544	604	544	548	542	684	678	696	534
Wt. out of feedlot (lb)									
Slaughter wt. (lb)	1058	940	962	1016	1012	1054	990	1016	890
No. days finishing	192	199	199	192	213	143	129	129	122
ADG finishing phase (lb)	2.37	1.82	1.87	1.87	2.21	1.84	1.89	2.14	2.22
Hot carcass wt. (lb)	610	590	558	595	595	578	565	593	490
24 hr. carcass wt. (lb)	600	580	550	584	586	569	554	583	483
% kid fat	2.5	3.5	4.0	3.0	2.0	2.5	3.5	3.0	2.5
Marbling score	4	5	3	6	4	4	4	4	4
Marbling texture	5	4	6	4	4	5	4	5	4
Texture of lean	6	4	7	7	5	6	4	5	5
Firmness of lean	6	3	6	6	5	6	6	6	6
Lean color	7	6	6	7	6	6	7	6	6
Fat color	4	5	4	4	4	4	4	4	4
Adjusted fat thickness	.40	.30	.30	.40	.30	.25	.50	.60	.30
Loin eye area	10.65	10.04	10.19	12.07	10.39	10.20	8.76	9.64	9.08
Grade	G+(11)	G(10)	S(7)	C(13)	G(10)	G(10)	G(10)	G(10)	G(10)

TABLE 3. (continued)

I.D. No.	Y7	B8	G8A	O8	W8	Y8A
Treatment	IP-CSM	IP-DPW	IP-DPW	IP-DPW	IP-DPW	IP-DPW
Weaning wt. (lb)	505	460	530	485	500	480
Wt. off IP (lb)	542	536	590	556	546	542
Beginning test wt. (lb)	636	598	680	652	652	610
Wt. out of feedlot (lb)						
Slaughter wt. (lb)	1030	1050	1042	1030	922	860
No. days finishing	143	174	136	167	129	136
ADG finishing phase (lb)	1.83	2.15	2.37	1.86	1.58	1.39
Hot carcass wt. (lb)	550	604	612	597	523	488
24 hr. carcass wt. (lb)	539	584	602	578	514	480
% kid fat	3.0	2.0	3.0	2.5	3.5	2.5
Marbling score	3	4	4	4	4	4
Marbling texture	6	5	7	4	4	6
Texture of lean	6	6	5	5	6	5
Firmness of lean	5	5	6	5	6	5
Lean color	7	6	6	6	6	7
Fat color	4	4	4	4	5	4
Adjusted fat thickness	.15	.30	.35	.30	.30	.22
Loin eye area	9.20	10.30	11.45	10.42	8.90	10.06
Grade	S(7)	G(10)	G(10)	G(10)	G(10)	G(10)

APPENDIX B

CONFINEMENT INTAKE STUDY

TABLE 1. CHEMICAL ANALYSIS OF INDICATORS AND CONSUMPTION DATA.

Animal	1	2	3	4	5	6	1	2	3	4	5
Period	1	1	1	1	1	1	2	2	2	2	2
Total feces (g)	2307	1943	1324	2063	2920	2156	2038	1941	1369	1897	2149
Crude fiber am (%)	41.41	40.35	40.36	40.63	41.08	41.33	39.61	39.70	42.04	42.57	40.76
Crude fiber noon (%)	41.55	41.43	41.87	41.91	40.66	40.99	39.22	39.27	42.33	42.56	41.39
Crude fiber pm (%)	42.13	48.06	42.79	41.84	42.82	40.97	42.96	39.94	41.61	41.37	40.36
Crude fiber total (%)	42.04	42.04	42.64	41.68	40.84	40.82	40.97	38.64	44.30	40.46	41.34
Lignin am (%)	9.76	9.88	10.10	9.86	10.30	10.83	8.71	9.85	10.48	10.42	8.75
Lignin noon (%)	10.92	10.63	10.92	9.86	9.31	10.72	8.99	8.99	10.70	10.58	8.86
Lignin pm (%)	11.56	12.71	11.39	10.29	10.68	11.23	10.44	9.20	10.93	9.55	8.48
Lignin total (%)	11.12	10.76	11.32	10.19	10.59	9.74	9.80	8.45	11.52	9.26	9.03
Nitrogen am (%)	1.70	1.68	1.85	1.86	1.72	1.86	1.78	1.70	1.66	1.70	1.76
Nitrogen noon (%)	1.75	1.73	1.67	1.62	1.61	1.86	1.85	1.63	1.64	1.69	1.73
Nitrogen pm (%)	1.74	1.71	1.79	1.72	1.82	1.88	1.96	1.55	1.79	1.66	1.77
Nitrogen total (%)	1.76	1.72	1.79	1.72	1.77	1.78	1.80	1.64	1.81	1.75	1.76
Cr_2O_3 am (%)	.58	.61	.78	.61	.56	.59	.65	.66	.73	.69	.66
Cr_2O_3 noon (%)	.58	.48	.79	.47	.47	.43	.60	.57	.73	.70	.60
Cr_2O_3 pm (%)	.54	.51	.69	.45	.40	.44	.65	.55	.78	.63	.54
Cr_2O_3 total (%)	.56	.55	.76	.50	.46	.57	.62	.61	.77	.65	.59
Grain intake (g)	523	479	348	523	566	566	871	871	696	871	871
Hay intake (g)	5230	4794	3486	5230	5665	5665	4358	4358	3486	4358	4358

TABLE 1. (continued)

Animal	1	2	3	4	5	6	1	2	3	4	5
Period	1	1	1	1	1	1	2	2	2	2	2
Crude fiber grain (%)	7.32	7.32	7.32	7.32	7.32	7.32	7.32	7.32	7.32	7.32	7.32
Crude fiber hay (%)	38.01	38.01	38.01	38.01	38.01	18.01	41.83	41.83	41.83	41.83	41.83
Lignin grain (%)	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90
Lignin hay (%)	3.16	3.16	3.16	3.16	3.16	3.16	3.56	3.56	3.56	3.56	3.56
Nitrogen grain (%)	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Nitrogen hay (%)	1.50	1.50	1.50	1.50	1.50	1.50	1.24	1.24	1.24	1.24	1.24
DMD*grain (%)	86.05	86.05	86.05	86.05	86.05	86.05	86.05	86.05	86.05	86.05	86.05
DMD hay (%)	52.08	52.08	52.08	52.08	52.08	52.08	48.96	48.96	48.96	48.96	48.96
DMD grain and hay (%)	53.84	53.84	53.84	53.84	53.84	53.84	56.20	56.20	56.20	56.20	56.20

*DMD = dry matter disappearance.

TABLE 1. (continued)

Animal	6	1	2	4	5	6	1	2	4	5	6
Period	2	3	3	3	3	3	4	4	4	4	4
Total feces (g)	2059	1986	1903	1822	2060	1679	1776	2077	1795	1357	1647
Crude fiber am (%)	40.11	37.74	39.53	35.93	38.24	36.87	36.14	37.96	33.65	35.44	37.00
Crude fiber noon (%)	41.55	41.43	41.87	41.91	40.66	40.99	39.22	39.27	42.33	42.56	41.39
Crude fiber pm (%)	41.44	35.02	37.91	34.76	36.48	35.39	35.74	41.81	35.95	35.58	34.51
Crude fiber total (%)	40.67	36.62	38.11	35.40	36.60	35.80	38.12	41.95	36.20	37.28	36.55
Lignin am (%)	8.81	7.00	7.53	7.19	6.63	6.67	7.21	8.49	6.12	6.46	8.06
Lignin noon (%)	9.55	6.71	7.65	7.53	6.65	7.00	7.69	9.20	6.91	6.81	7.26
Lignin pm (%)	10.50	6.65	7.43	7.13	6.08	6.71	7.63	9.75	7.79	7.36	7.52
Lignin total (%)	9.05	6.85	7.98	7.05	6.24	6.45	8.15	9.80	7.01	7.62	8.16
Nitrogen am (%)	1.70	1.78	1.83	2.05	1.75	1.88	2.09	2.10	2.12	2.00	2.13
Nitrogen noon (%)	1.70	1.98	1.89	2.14	1.74	1.89	2.40	1.99	2.27	2.15	2.22
Nitrogen pm (%)	1.84	1.82	2.08	2.23	1.78	1.98	2.12	1.96	2.27	2.22	2.41
Nitrogen total (%)	1.82	1.96	1.85	2.03	1.91	1.91	2.11	1.97	1.12	2.03	2.23
Cr_2O_3 am (%)	.66	.58	.65	.62	.59	.64	.59	.57	.56	.52	.70
Cr_2O_3 noon (%)	.57	.51	.51	.51	.46	.50	.55	.48	.56	.45	.48
Cr_2O_3 pm (%)	.56	.42	.47	.50	.42	.45	.44	.44	.44	.47	.53
Cr_2O_3 total (%)	.50	.48	.50	.59	.54	.51	.53	.53	.53	.58	.60
Grain intake (g)	871	2615	2615	2615	2615	2615	3267	3267	3267	3267	3267
Hay intake (g)	4358	2615	2615	2615	2615	2615	2179	2179	2179	2179	2179

TABLE 1. (continued)

Animal	6	1	2	4	5	6	1	2	4	5	6
Period	2	3	3	3	3	3	4	4	4	4	4
Crude fiber grain (%)	7.32	8.90	8.90	8.90	8.90	8.90	7.62	7.62	7.62	7.62	7.62
Crude fiber hay (%)	41.83	39.97	39.97	39.97	39.97	39.97	39.22	39.22	39.22	39.22	39.22
Lignin grain (%)	.90	1.08	1.08	1.08	1.08	1.08	.85	.85	.85	.85	.85
Lignin hay (%)	3.56	4.27	4.27	4.27	4.27	4.27	4.06	4.06	4.06	4.06	4.06
Nitrogen grain (%)	1.50	1.58	1.58	1.58	1.58	1.58	1.54	1.54	1.54	1.54	1.54
Nitrogen hay (%)	1.24	1.46	1.46	1.46	1.46	1.46	1.68	1.68	1.68	1.68	1.68
DMD*grain (%)	86.05	81.00	81.00	81.00	81.00	81.00	79.41	79.41	79.41	79.41	79.41
DMD hay (%)	48.96	47.84	47.84	47.84	47.84	47.84	48.83	48.83	48.83	48.83	48.83
DMD grain and hay (%)	56.20	65.36	65.36	65.36	65.36	65.36	68.51	68.51	68.51	68.51	68.51

*DMD = dry matter disappearance.

TABLE 1. (continued)

Animal	1	2	4	5	6
Period	5	5	5	5	5
Total feces (g)	2301	1550	2218	1905	1959
Crude fiber am (%)	35.25	36.92	31.45	33.49	36.53
Crude fiber noon (%)	34.84	36.32	30.89	33.16	33.28
Crude fiber pm (%)	34.27	36.99	32.91	30.85	32.65
Crude fiber total (%)	35.92	36.52	32.01	32.66	33.94
Lignin am (%)	5.18	6.09	4.34	4.76	5.11
Lignin noon (%)	5.31	5.94	4.49	4.55	4.94
Lignin pm (%)	5.74	6.37	4.88	4.51	4.88
Lignin total (%)	5.38	6.53	5.03	4.77	5.13
Nitrogen am (%)	1.82	1.84	1.87	1.99	1.76
Nitrogen noon (%)	1.83	1.91	2.01	1.73	2.00
Nitrogen pm (%)	2.06	1.86	1.99	2.13	2.19
Nitrogen total (%)	1.90	1.79	1.98	2.07	1.95
Cr_2O_3 am (%)	.51	.68	.38	.51	.53
Cr_2O_3 noon (%)	.36	.61	.38	.33	.37
Cr_2O_3 pm (%)	.38	.61	.37	.41	.38
Cr_2O_3 total (%)	.47	.63	.45	.51	.45
Grain intake (g)	4358	3267	4358	4358	4358
Hay intake (g)	1743	1307	1743	1743	1743

TABLE 1. (continued)

Animal	1	2	4	5	6
Period	5	5	5	5	5
Crude fiber grain (%)	10.28	10.28	10.28	10.28	10.28
Crude fiber hay (%)	39.34	39.34	39.34	39.34	39.34
Lignin grain (%)	1.21	1.21	1.21	1.21	1.21
Lignin hay (%)	3.18	3.18	3.18	3.18	3.18
Nitrogen grain (%)	1.49	1.49	1.49	1.49	1.49
Nitrogen hay (%)	1.26	1.26	1.26	1.26	1.26
DMD*grain (%)	78.43	78.43	78.43	78.43	78.43
DMD hay (%)	52.02	52.02	52.02	52.02	52.02
DMD grain and hay (%)	67.95	67.95	67.95	67.95	67.95

* DMD = dry matter disappearance.

APPENDIX C

COMMENTS ON ESTIMATES OF FORAGE CONSUMPTION UNDER GRAZING CONDITIONS

COMMENTS ON ESTIMATES OF FORAGE CONSUMPTION UNDER GRAZING CONDITIONS

In order to further examine the indicators used in Chapter 2, a study was designed which would compare the indicator techniques to estimates of forage consumption based on before and after grazing of steers on irrigated pasture. The steers were group fed barley. Ten grams of chromic oxide were added per steer to the daily feed. Fresh fecal samples were collected from at least three steers ten hours following feeding for analysis of chromic oxide, lignin, crude fiber and nitrogen. Representative forage samples were also collected by observing grazing animals and clipping forage similar to what they were eating. Forage concentrations of lignin, crude fiber and nitrogen were determined based on forage samples.

Before and After Grazing Technique. Two cages six meters in diameter were placed in each irrigated pasture where the steers from trial 2 were grazing. Paired plots were located outside each cage. Two one meter plots were clipped inside the cage to measure available forage prior to the animals being turned in to graze the pasture. These plots were clipped again on the day animals were removed from pasture to obtain regrowth. Two one meter plots at the location of the paired plots outside each cage were clipped to give an estimate of forage remaining in the pasture. Two one meter plots were clipped inside the cage after grazing to determine the amount of available forage if no grazing had occurred. All of the samples were dried in a 45 C oven and then weighed to the nearest gram. Total production was calculated by adding the clippings before, inside after and the regrowth, then dividing the total by two. The clippings outside after were subtracted from this to yield the estimated intake in grams of dry matter.

Fecal production was estimated by the chromic oxide method. Using this estimate of fecal production, intake was then estimated by use of fecal concentrations of lignin, crude fiber and nitrogen. These estimates of intake were correlated to the actual as measured by the before and after grazing technique. The correlation coefficients were .0186, -.4093 and -.5062 for lignin, crude fiber and nitrogen respectively. Preliminary work as reported in Chapter 2 indicated that lignin and crude fiber would be the best indicators of intake.

Since the steers from the irrigated pasture had to be fed hay in drylot during the finishing phase, chromic oxide feeding was continued at the rate of ten grams per head to compare actual forage intake to that predicted by lignin, crude fiber and nitrogen. The correlation coefficients for actual to estimated intake were .0773, .4396 and .7728 for lignin, crude fiber and nitrogen respectively.

Due to the poor correlation coefficients the indicator techniques were not utilized to predict forage intake on range or irrigated pasture. The indicator contributing the greatest error to the estimate was most likely chromic oxide and it's estimate of fecal production. The use of fecal bags to collect feces is most likely the best way to overcome this problem. However, the use of fecal bags may change the grazing behavior of the animal. They were not used in this study in order to determine if reliable estimates could be made without physically restricting the animal. Thus, it was concluded that reliable estimates could not be made using this technique.

KEY TO THE TABLES OF APPENDIX C

Treatments: AO = alfalfa-orchard grass
AF = alfalfa-fescue
FALL = fall steers
CW = crested wheatgrass

Indicators: N = nitrogen
CF = crude fiber
L = lignin

Forage FI = forage intake as measured by before and after clipping.

Forage HI = actual hay intake.

TABLE 1. CHEMICAL ANALYSIS OF FORAGE, GRAIN AND FECAL SAMPLES OF STEERS GRAZING IRRIGATED PASTURE, GROWING PHASE, TRIAL 2

		Feces				Forage				Grain			
Trt.	Date	Cr_2O_3	N	CF	L	FI	N	CF	L	N	CF	L	Amt. Fed
		%	%	%	%	(g)	%	%	%	%	%	%	(g)
AO	5/27	.40	2.81	41.89	10.75	8249	3.50	2.301	2.79	1.63	11.53	1.32	1362
AO	6/8	.27	2.73	40.13	11.22	10737	3.36	28.96	3.51	1.63	11.53	1.32	1362
AO	6/21	.43	2.56	40.32	9.86	8930	3.00	30.19	3.54	1.63	11.53	1.32	1362
AO	7/6	.28	2.49	42.46	11.58	9443	2.46	32.71	3.64	1.63	11.53	1.32	1362
AO	7/19	.31	2.16	43.09	10.82	11863	3.28	31.24	3.22	1.63	11.53	1.32	1362
AO	7/27	.24	2.36	43.29	12.22	8008	3.73	29.66	4.91	1.63	11.53	1.32	1362
AF	5/27	.50	2.32	43.98	6.77	8299	2.39	29.15	1.85	1.63	11.53	1.32	1362
AF	6/8	.02	2.10	44.48	8.09	2592	2.32	33.77	2.64	1.63	11.53	1.32	1362
AF	6/21	.18	1.84	48.54	7.90	4553	2.15	36.23	2.97	1.63	11.53	1.32	1362
AF	7/6	.19	1.74	47.63	7.59	5806	1.66	38.44	3.04	1.63	11.53	1.32	1362
AF	7/19	.20	1.87	44.58	8.63	11685	2.47	34.32	2.49	1.63	11.53	1.32	1362
AF	7/27	.20	1.61	48.72	8.83	7363	1.54	40.50	4.43	1.63	11.53	1.32	1362

TABLE 2. CHEMICAL ANALYSIS OF HAY, GRAIN AND FECAL SAMPLES OF STEERS IN DRYLOT, FINISHING PHASE, TRIAL 2

	Feces				Forage				Grain			
Date	Cr_2O_3	N	CF	L	HI	N	CF	L	N	CF	L	Amt. Fed
	%	%	%	%	(g)	%	%	%	%	%	%	(g)
8/15	.39	2.22	43.55	1117	7658	1.61	40.06	5.75	1.69	12.53	1.39	1816
8/29	.26	2.13	42.99	1063	6592	1.84	37.32	4.10	1.90	12.29	1.42	3178
9/11	.26	2.35	39.69	844	5411	2.07	40.73	4.82	1.83	9.11	1.13	4994
9/22	.30	2.19	37.50	737	4866	1.82	38.42	3.86	1.85	12.98	1.70	6356
9/25	.19	2.43	33.92	779	4866	1.48	38.81	3.88	1.85	12.98	1.70	6810
11/3	.22	2.28	34.86	722	5248	1.24	38.83	4.38	1.91	12.00	1.35	6810

TABLE 3. CHEMICAL ANALYSIS OF FORAGE, GRAIN AND FECAL SAMPLES OF STEERS GRAZING CRESTED WHEATGRASS, GROWING PHASE, TRIAL 2

		Feces				Forage			Grain			
Trt.	Date	Cr_2O_3	N	CF	L	N	CF	L	N	CF	L	Amt. Fed
		%	%	%	%	%	%	%	%	%	%	(g)
Fall	6/1	.12	2.45	42.71	9.81	2.11	27.98	2.68	1.56	16.74	2.16	908
Fall	6/16	.09	1.76	48.57	10.94	1.76	32.93	4.30	1.56	16.74	2.16	908
Fall	6/30	.14	1.76	47.02	13.29	1.44	38.06	5.83	1.56	9.20	1.23	908
Fall	7/14	.14	1.53	48.56	13.78	1.01	38.01	5.59	1.56	9.20	1.23	908
CW	6/1	.46	2.73	39.32	9.14	2.16	27.61	2.59	1.56	16.74	2.16	454
CW	6/16	.23	2.09	44.93	11.50	1.91	31.97	3.80	1.56	16.74	2.16	454
CW	6/30	.09	1.97	46.12	14.75	1.31	36.41	5.28	1.56	9.20	1.23	454
CW	7/14	.17	1.65	48.04	14.32	1.09	37.58	5.40	1.56	9.20	1.23	726
CW	7/26	.19	1.36	50.69	12.53	.91	41.98	6.06	1.56	9.20	1.23	1135

TABLE 4. CHEMICAL ANALYSIS OF FORAGE, GRAIN AND FECAL SAMPLES OF STEERS GRAZING CRESTED WHEATGRASS, FINISHING PHASE, TRIAL 2

Date	Feces				Forage			Grain			
	Cr_2O_3	N	CF	L	N	CF	L	N	CF	L	Amt. Fed
	%	%	%	%	%	%	%	%	%	%	(g)
8/15	.11	1.24	52.18	12.40	.88	40.39	5.76	1.75	10.42	1.21	20.43
8/29	.21	1.53	50.04	12.11	.79	42.47	5.63	1.75	10.42	1.21	34.05
9/11	.19	1.64	42.66	10.35	1.11	40.40	6.71	1.75	10.42	1.21	49.94
9/22	.21	1.91	42.59	10.36	.74	46.14	4.80	1.94	8.56	1.01	68.10
9/25	.20	1.71	43.55	9.97	.64	48.14	5.31	1.94	8.56	1.01	68.10
11/3	.22	1.66	47.17	8.49	.41	51.38	5.79	1.92	9.27	1.05	68.10

APPENDIX D

ANALYSIS OF VARIANCE

TABLE 1. ANALYSIS OF VARIANCE FOR DAILY GAINS.

Item	Mean Square (df) Treatment	Error	F
Trial 1, 1976			
Growing phase	4.94(2)	.08(59)	61.75**
Finishing phase	1.49(4)	.24(52)	6.22**
Trial 2, 1977			
Growing phase	.86(2)	.08(36)	10.75**
Finishing phase	1.98(6)	.16(32)	12.33**
Trial 3, Fall Steers			
Finishing phase	.62(4)	.06(25)	10.33**

$^{**}P<.01$.

TABLE 2. ANALYSIS OF VARIANCE FOR TASTE PANEL EVALUATION.

	Trial 1, 1976			Trial 2, 1977		
	Mean Square			Mean Square		
Item	Treatment	Error	F	Treatment	Error	F
Degrees of freedom	4	45		6	63	
Aroma	.376	.665	.56	.650	.621	1.05
Tenderness	26.56	1.27	20.87**	18.75	1.06	17.56**
Juiciness	8.06	1.11	7.26**	2.43	1.21	2.00
Flavor	2.22	.778	2.86*	.808	.869	.93
Overall desirability	9.79	.989	9.90**	5.15	.834	6.18*

$^{*}P<.05$.
$^{**}P<.01$.

TABLE 3. ANALYSIS OF VARIANCE FOR CARCASS CHARACTERISTICS.

	Trial 1, 1976			Trial 2, 1977			Trial 3, Fall Calves		
	Mean Square			Mean Square			Mean Square		
Item	Treatment	Error	F	Treatment	Error	F	Treatment	Error	F
Degree of freedom	4	45		6	32		4	25	
24 hr. carcass wt.	26186.9	1597.8	16.39**	7085.3	2101.8	3.37*	2050.2	1571.3	1.30
Carcass grade	9.19	2.82	3.26*	4.39	2.25	1.95	2.53	3.65	.69
Marbling score	1.11	.43	2.58*	.69	.40	1.73	.44	.80	.55
Rib eye area	1.89	1.04	1.82	3.36	.89	3.78**	3.56	.90	3.96*
Fat color	5.10	.31	16.45**	.79	.11	7.18**	3.74	.18	20.78**

*$P<.05$.

**$P<.01$.