THE EFFECT OF VARIOUS LEVELS OF ROUGHAGES AND VARIOUS GRAINS ON THE GROWTH PATTERNS OF GROWING AND FATTENING STEERS

by

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ABSTRACT

In Study I alfalfa-bermuda grass hay or oat straw was fed with rolled barley, pelleted beet pulp, soybean oil meal and cracked wheat, in various proportions, in twenty protein-supplemented rations to immature Hereford steers. A control ration of 10% long straw, 78% rolled barley and 12% soybean oil meal was included. The best results were obtained with a roughage level of 10%. However, it was shown that it was feasible to feed roughage levels as high as 40% without detrimental effects to either average daily gain, feed efficiency, or carcass quality.

In Study II various feed grains were fed in the ratio 90:10 (concentrate to roughage). The Canadian feed grains of barley and wheat were compared with corn. Various ratios of these feed grains were also compared. Excellent gains and feed efficiencies were obtained on all rations and it was shown that the cost of the grains available would be the largest factor in determining which to use.

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INTRODUCTION

Ruminants are unique in that they foster in their complex stomach a microbial population. This association is required for the animals' well-being. Physiologically and anatomically, the ruminant is adapted to utilize roughage. When it is realized that over 60% of the world's agricultural land is non-arable and only suited for the production of roughage feeds or for grazing, then cattle, sheep, and certain wild animals, are the only practical means, at least at present, of utilizing this vast feed resource for the production of food for man.

Most cattle feeds are made up largely of roughages and concentrates. The main difference between roughages and concentrates is in the amount of fibre they contain. Concentrates are low in fibre with few of the common ingredients of grain (concentrate) rations having over 10% fibre. The amount of fibre in roughages varies, with hay crops averaging 28% crude fibre, and straws 38%. The fibre component of the feed is composed mainly of cellulose, hemicellulose, and lignin, and is dependent on the state of maturity of the plant. Digestion of the forage generally becomes less efficient with increasing fibre content. This fibre component of roughages is largely carbohydrate but, because of its insoluble nature, it is only partially utilized as a food nutrient by ruminants. The unique digestive system of the ruminant has prompted much work on the utilization of high cellulose feeds in growing rations.

In recent years, there has been a trend to feed beef cattle high-energy low-fibre rations. Even though steers and heifers can be finished on diets lacking roughage, this procedure is not without hazards and offers little to the over-all efficiency of beef cattle production. Research has indicated that there is a practical minimal level for roughage fed to animals receiving "high energy diets". It is felt by many that a physical roughness factor in the ration is required for the rumen to maintain its normal functioning pattern.

The Food and Agriculture Organization of the United Nations (FAO 1971) has made a large number of agricultural commodity projections which emphasize the importance of research in beef production. The projections are for the time period of 1970-1980. They project that in 1980 the annual wheat production in Canada will be about the same as the annual production obtained in the base period of 1964-1966; however, less acreage will be involved. It is interesting to note that the projected production of both corn and barley, however, will be better than 200% of the annual production in the base period of 1964-1966.

The annual production of beef and veal in North America in 1964-1966 was 9.73 million tons, with an average carcass weight of 481 pounds. In 1970 this production increased to 11.24 million tons, with an average carcass weight of 506 pounds. The projected annual production for beef and veal in 1980 in North America is 14.09 million tons, with an average carcass weight of 590 pounds.

In the 1964-1966 base period in North America, the annual average per capita consumption of beef and veal was 105 pounds. By 1970 this had risen to 115 pounds. The projected increase by 1980 shows an annual per capita demand for beef and veal of 133 pounds. When this is coupled with the large increase in population expected and the role North America may be able to play in helping those countries of lower economic status, the growth expected in the beef industry alone can only be considered as phenomenal. The world level of total annual demand for beef and veal is projected to be approximately 200% of the annual demand in the

1964-1966 base period, which was 32.83 million metric tons.

This Study is divided into two sections. In Study I, different roughage sources and levels were fed with various grains in a cattle feeding trial. It has generally been considered that high roughage fattening rations have an undesirable effect on carcass composition. An assessment of the carcass characteristics of those animals in the feeding trial was made. As roughage content of a feed has a marked effect on the ration digestibility this Study included digestibility evaluations of the experimental rations.

In Study II, a feeding trial was conducted where the roughage to concentrate ratio of the diet remained the same with variations within the concentrate proportion. The primary aim of this Study was to demonstrate the capacity of corn, barley, and wheat to elicit comparable results, and to investigate the effect of mixing the grains in various proportions.

STUDY I

THE EFFECT OF VARIOUS LEVELS OF ROUGHAGES ON THE GROWTH PATTERNS OF GROWING AND FATTENING STEERS

A. INTRODUCTION

The most efficient utilization of feed in fattening beef steers is associated with high rates of gain, which means high daily feed intakes and high percentages of grain in the ration. The characteristics of high grain rations that produce this efficiency are a high concentration of energy and low bulk. Further advantages of using these rations are ease of mechanical handling with a lower labour cost, and a greater turnover of animals in the feedlot, with a resultant higher capital turnover than could be achieved with high-roughage rations.

There are, however, disadvantages in using high grain rations. These include a possible occurrence of rumen parakeratosis, liver abscesses, founder and bloat.

This study involves a feeding trial examining the inclusion of low-quality roughages in intensive fattening rations. This also includes an inspection of the effects of the feeding trial on carcass characteristics. Digestibility studies of the experimental rations were done in order to assess more accurately the use of low-quality roughages in beef cattle rations.

In terms of obtaining the most efficient use of the beef animal, modification of the roughage to cereal ratio shows great promise in maximizing production from grain based diets. Economy in the utilization of cereal energy and nitrogen can only be achieved under intensive specialized conditions of production, and the beef producer is greatly in need of quantitative information on dietary balance in order to maximize output.

B. LITERATURE REVIEW

The unique digestive system of cattle has prompted much work on the incorporation of high cellulose feeds into efficient growing rations. Beeson and Perry (1952) stated that "at present, a large proportion of roughages (corn cobs, soybean straw, oat straw and grass silage) is being wasted through improper use. Each year, over 20 million tons of corn cobs are produced, but by far the larger share is burned or thrown out to rot". In five experiments, using immature Hereford steers, Beeson and Perry (1952) were able to obtain gains of 1.28 to 1.56 pounds daily by feeding ground corn cobs and protein, and 2.06 to 2.21 pounds daily gain when corn silage and protein supplement were fed.

The feeding of all-concentrate diets to ruminants is not a new concept. However, the effects of feeding all-concentrate diets to immature growing animals are very interesting. Davenport (1897) was unsuccessful in attempts to rear calves on rations devoid of roughage, and concluded that fibrous materials were necessary in the ruminant diet. This fact was confirmed by several experimenters. Huffman (1928) postulated an "unknown factor" in hay necessary to maintain the health of cattle. Geurin <u>et al</u> (1959)

fed concentrate diets supplemented with barley which was rolled to preserve the roughage characteristics of the hulls. These workers reported gains up to 2.95 pounds per day on a 32% protein supplement and rolled barley. Bond (1966) conducted an experiment using an all-concentrate corn ration versus a roughage ration. He reported faster gains and lower feed conversion rates by the animals on the all-concentrate ration.

Although high-concentrate rations result in better gains and feed conversion than do high-roughage rations and show a better adaption to mixing, handling and storage, several important and costly side effects can occur. A report by Haskins et al (1969) summarized some of the effects of high-concentrate rations as follows:

1. A high incidence of rumen parakeratosis and liver abscesses in animals fed high-energy rations occurred.
2. Inclusion of roughage (hay) drastically reduced (from 67% to 0%) the incidence of abscessed livers, indicating that the physical properties of the roughage source are involved.
3. Rapid accumulation of volatile fatty acids, lactic acid, and lowering of rumen pH, which

may be antagonistic to the rumen epithelium, were observed.

In a trial conducted by Cullison (1961), the effects of grinding and pelleting a ration containing 30% Bermuda grass hay and 50% ground shelled corn with protein and mineral supplements, and the effects of including long oat straw on fattening calves, were studied at slaughter, following feeding periods of 196 and 210 days respectively. Varying degrees of an abnormal rumen wall were observed in animals on both ground and pelleted rations. The papillae of the rumen of these calves appeared dark and excessively long. Keratinous tissue was sloughing off some areas of the rumen wall. Those animals on a control ration of concentrates and long hay exhibited a normal rumen wall, while those which received straw with the basic ration, exhibited a yellowish but otherwise normal rumen.

From studying experiments involving the use of roughage substitutes, it seems that the inclusion of roughage per se in the form of hay or straw is desirable. The great majority of feedlot operators are paid on the basis of a visual evaluation of the live animals rather than an evaluation of the carcass produced. They are not penalized for bad livers on either system. They may feel, therefore, that increased feed efficiency, rate of gain and ease of feed handling, offset the risk of digestive upsets common with high-grain rations.

All-grain rations have been fed successfully. However, they appear to be most successful with high-fibre grains such as oats or barley, rolled so as to retain a fibrous consistency. Hironaka et al (1962) conducted an experiment to determine the effects of level of feed consumption of an all-barley ration on rate and efficiency of gain by steers. The barley was fed dry, crimped with a mineral-vitamin supplement at levels calculated to produce a gain of 1.0, 1.5, 2.0, and 2.5 pounds per day. The corresponding feed conversions (lbs. feed/lbs. gain), were 10.92, 8.51, 7.02, and 7.05. Randomly five of the steers became chronic bloaters, and one steer had small liver abscesses.

Assuming that a certain amount of roughage is necessary in the rations of feedlot cattle, the exact proportions of concentrate to roughage must be known if maximum performance is to be obtained from them. A general recommendation is that a minimum of 10% roughage be included in a ration to prevent digestive upsets. If the roughage percentage is increased, lower rates of gain and decreasing feed efficiency will occur.

Experiments using various levels of roughage in the ration have been carried out. Richardson _et al_ (1961), using roughage to concentrate ratios of 1:1, 1:3, and 1:5 of alfalfa hay and cracked sorghum grain, found the highest average gain was with the 1:5 ratio.

White and Reynolds (1969), using 20% and 40% alfalfa hay as the roughage source, with ground sorghum grain and soybean meal as the concentrate sources, showed that consumption of a ration containing 40% hay was higher than that of a ration containing 20% roughage, and higher than the consumption of the all-concentrate ration. They showed that the source of roughage influenced the gain and carcass weights. Swan and Lamming (1969) cited research at the University of Illinois where trials were conducted using concentrate-roughage ratios varying from 80:20 to 0:100 on all-pelleted rations containing ground shelled corn and soybean oil meal with ground hay as the roughage source. Highest average daily gains were obtained with a 60:40 concentrate to roughage ration. Best feed conversion was with the 80% concentrate ration, but average daily gain did not increase by raising the concentrate level from 60% to 80%. Feed intake was reduced at the 80% concentrate level, with the best dressing percentages at the high levels of concentrates.

Performance and feed conversion efficiencies have been shown to improve with higher concentrate rations. The higher levels of concentrates have improved dressing percentages, carcass grades, and brought about a reduction in the finishing times required for marketing. Several costly side effects become more frequent with higher grain levels and, consequently, better management practices are necessary.

Local conditions and availability will determine which feeds are most economical; the cost of different feeds, in relation to their nutritive value, being an important consideration. When deciding upon the most economical ration to feed, rate and efficiency of live weight gain, as well as dressing percentage and carcass grade expected, must also be considered.

Digestion trials with animals fed total mixed rations has, in the past, generally involved confinement to digestion crates or the use of fecal collection apparatus. Ellenberger et al (1927), Noblitt et al (1963), and Waldo et al (1961), have reported that stress significantly affects the digestibility of nutrients.

Much of the work which has been conducted with the use of chromic oxide as an external indicator of digestibility has been devoted to techniques which will result in samples that are representative of the total fecal excretion. Crampton and Lloyd (1951) reported satisfactory coefficients of digestibility with sheep when random samples were taken daily for four days and composited for each animal. Bradley (1958) found close agreement between digestion coefficients for crude protein and gross energy calculated from: total collection of feces, twice daily samples, and 7-day composited samples for steers in metabolism crates. Digestion coefficient of a nutrient is described as:

$$\text{Digestion coefficient} = 100 \left(\frac{a-b}{a} \right)$$

where a = parts of nutrient/unit of index substance in food.

b = parts of nutrient/unit of index substance in feces.

Many experiments quoted by Schurch *et al* (1950) indicate that the Cr_2O_3 method can replace the conventional procedures for determining digestibility of rations or nutrients consumed. As a main advantage, the method leads to a simplified experimental procedure by avoiding the necessity of a quantitative record of either food intake or feces output. The chemical work, however, is increased by the necessity to determine the Cr_2O_3 content of feed and feces. An easy, rapid and acceptably-accurate analytical method of Cr_2O_3 is, therefore, of primary importance.

Recent work, designed to study the effect of fecal collection apparatus on the digestibility of nutrients by steers fed a complete pelleted ration ad libitum, and to compare total collection versus chromic oxide indicator digestibility coefficients, was completed by Phar et al (1971). Their results generally indicated no significant difference between methods employed.

C. MATERIALS AND METHODS

(a) Feeding Trial

Experimental Design

The experimental animals were randomly allocated to twenty pens with each pen randomly receiving one of twenty experimental rations. The animals were slaughtered when they reached a live weight of 454-477 kilograms. One animal from each ration group was retained at the conclusion of the feeding trial to facilitate a digestibility trial.

Experimental Animals

The experimental animals (100 Hereford steer calves) were obtained from the Douglas Lake Cattle Co., Douglas Lake, B.C., and were selected on the basis of uniform body weights and conformation. The average weight of the animals when received at the feedlot was 200 kilograms. The steers were all ear-tagged and allocated at random to pens, five animals in each.

Housing

Each group was confined in a 3.65 meter by 9.14 meter pen, allowing each animal 6.67 square meters of area. Each pen was bedded with wood shavings, and shavings were added as needed. Water and cobalt-iodized salt blocks were provided *ad libitum* to all groups.

Initial Treatment and Feeding Procedure

On arrival at the experimental facilities, the animals were fed alfalfa-bermuda grass hay (long form). The animals were given injections of Provite[1] (1 cc.) (Vitamins A, D_2, and E), to prevent or correct any vitamin deficiencies, and Rea-Plex[2] (2 cc.) for prevention of infectious bovine rhinotracheitis. The hay diets were supplied for 17 days, and grain was added on day 17, at 1.9 kg/animal/day. The experimental vitamin-mineral Premix[3] was added at .45 kg/animal/day on day 24, and the hay constituent was added in the chopped form on day 25. The animals were given a full 5-week transition period and were on

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Source: 1 Ayerst Laboratories, Division of Ayerst, McKenna & Harrison Limited, Montreal, Quebec.

2 Fort Dodge Laboratories Inc., Fort Dodge, Iowa.

3 Vitamin-Mineral Premix Composition Table III.

full experimental rations by day 35. All steers were subcutaneously implanted in the ear with 36 mg of Diethylstilbestrol (DES) to obtain increased feed efficiencies and rate of gain that had been obtained in the literature.

The daily feeding procedure during the experiment involved feeding once per day, each morning. On weighing days, feed was withheld one hour until weighing was completed. The animals were fed as much as they could consume in 24 hours (full feed).

Rations

Rations were designed to not be limiting nutritionally and to be isonitrogenous. Ration compositions are given in Tables I and II. Protein and Vitamin-Mineral Premix composition are given in Table III. Methods of analysis used are those published by the Association of Official Agricultural Chemists (1960).

TABLE I

CONSTITUENTS OF RATIONS INCORPORATING STRAW
(air dry basis)

(Day 1 - Day 150)

Ration	Straw %	Barley %	Wheat %	Beet Pulp %	Soybean oil meal %
1	#L 10	78			12
2	C 10	78			12
3	C 25	60			15
4	C 40	42			18
5	C 10	61.6		15.4	13
6	C 25	47.2		11.8	16
7	C 40	33.2		8	18.5
8	C 10		82.5		7.5
9	C 25		63.5		11.5
10	C 40		44		16

(Day 150 - Slaughter)

Ration	Straw %	Barley %	Wheat %	Beet Pulp %	Soybean oil meal %
1	C 10	78			12
2	C 10	78			12
3	C 10	78			12
4	C 10	78			12
5	C 10	61.6		15.4	13
6	C 10	61.6		15.4	13
7	C 10	61.6		15.4	13
8	C 10		82.5		7.5
9	C 10		82.5		7.5
10	C 10		82.5		7.5

#Letter (L) or (C) before Straw Percent denotes long or chopped.

N.B. In addition to the indicated ration each animal received .45 kg per day of the experimental Vitamin-Mineral supplement.

TABLE II

CONSTITUENTS OF RATIONS INCORPORATING HAY
(air dry basis)

(Day 1 - 95)

Ration	Hay %	Barley %	Wheat %	Beet Pulp %	Soybean oil meal %
11	#L 10	81			9
12	C 10	81			9
13	C 25	69			6
14	C 40	56.5			3.5
15	C 10	64		16	10
16	C 25	51.4		13.6	7.0
17	C 40	44.8		11.2	4.0
18	C 10		86		4
19	C 25		73.5		1.5
20	C 40		60		

(Day 95 - 150)

Ration	Hay %	Barley %	Wheat %	Beet Pulp %	Soybean oil meal %
11	L 10	90			
12	C 10	90			
13	C 25	75			
14	C 40	60			
15	C 10	74		16	
16	C 25	61.4		13.6	
17	C 40	48.8		11.2	
18	C 10		90		
19	C 25		75		
20	C 40		60		

(Day 150 - Slaughter)

Ration	Hay %	Barley %	Wheat %	Beet Pulp %	Soybean oil meal %
11	C 10	90			
12	C 10	90			
13	C 10	90			
14	C 10	90			
15	C 10	74		16	
16	C 10	74		16	
17	C 10	74		16	
18	C 10		90		
19	C 10		90		
20	C 10		90		

#Letter (L) or (C) before Hay Percent denotes long or chopped.

N.B. In addition to the indicated ration each animal received .45 kg per day of the experimental Vitamin-Mineral supplement.

TABLE III

COMPOSITION OF EXPERIMENTAL PREMIX

Vitamin-Mineral Supplement

Vitamin A	-	140 gm (325,000 I.U. per gm)
Vitamin D	-	120 gm (80 million I.U. per lb.)
$CuSO_4$	-	40 gm
$CoSO_4$	-	40 gm
$MnSO_4$	-	600 gm
$ZnSO_4$	-	1000 gm
Prodine	-	36 (170 mg Iodine per gm)

Experimental Premix

(fed at .45 kg per head per day)

Vitamin Mix as above	-	4.5 kg
Limestone	-	63.6 kg
Dicalcium Phosphate	-	45.4 kg
Salt	-	72.7 kg
Barley	-	618.1 kg
Shorts	-	90.8 kg
Tallow	-	13.6 kg
Total		909 kg

Weighing Procedure

Weighing of all experimental cattle was done bi-weekly. After being weighed a few times, the animals became accustomed to the procedure and the operation was done with a minimum of disturbance.

Ration Costs

Costs of all ration constituents and other miscellaneous costs are given in Table IV. Soybean oil meal was the most expensive constituent at $131.00 per ton. Ration costs were reasonably low considering that the feedlot was a considerable distance from the areas of feed production.

TABLE IV

COSTS OF MATERIALS

Hay	$51.80/ton	(metric)	($47.00/ton	(Short))		
Straw	$38.58	"	"	($35.00	"	")
Barley	$57.32	"	"	($53.00	"	")
Wheat	$69.44	"	"	($63.00	"	")
Beet Pulp	$71.65	"	"	($65.00	"	")
Experimental Premix	$88.18	"	"	($80.00	"	")
Soybean oil meal	$144.40	"	"	($131.00	"	")

Other Costs

Ear Tags	- Re-usable
Scale	- $30.00 (maintenance)
Salt Blocks	- $22.50
Diethylstilbestrol implants	- $35.00 (3.5 cents/animal)

Cattle

100 head -	49,810 @ 38.50 cwt.	$19,176.85
	less 4% shrink	767.04
		18,409.81
	plus freight @ .75/cwt.	358.64
		$18,768.45

(b) Management Procedures

Adaption

The animals adapted exceedingly well to the rations and the experimental environment. All were shipped directly from range conditions and, immediately upon arrival at the experimental facilities, were started on solid food. No shipping fever was evident and all quickly adapted to the feedlot environment.

Ringworm Control

An outbreak of ringworm (*Trichophyton verrucosum*) occurred during the experiment, afflicting, in varying degrees, over 70% of the animals. The outbreak was controlled with topical applications of Capitan[1] and motor oil to infected areas. The infection subsided following repeated applications.

Bloat in Animals

One animal in Group 17 (#20), on a ration containing 40% straw, began bloating on day 65. Treatment by drenching with 6 ounces of Turcapsol[2] and hosing was successful. The

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1 Canadian Industries Ltd., Vancouver, British Columbia.

2 Pitman Moore, Don Mills, Ontario.

animal again bloated on day 80 and was treated again. Bloating repeated again on day 90, and treatment had no effect after that date. Consequently the animal was slaughtered on day 96, and dressed at 154.5 kg with a dressing percentage of 57%.

Ration Adjustments

The ration adjustments were made for two basic reasons:

1. Grass hay was no longer available and switching to alfalfa hay caused an increase in the protein content of rations 11-20.
2. Animals had reached 286-348 kg live weight at this time, and rations would have had protein levels of 13.97% to 16.9%. The National Research Council recommendation is 10.4% total protein.

On day 95 of the experiment, soybean oil meal was eliminated from the hay rations. All other ration concentrate constituents were raised to give 100% totals.

(c) Carcass Trial

The animals were slaughtered when they reached a live weight of 454-477 kilograms. The following data were collected:

1. Shipping weight
2. Hot carcass weight
3. Government grade
4. Rib eye measurement
5. Fat cover measurement

The shipping weight of each animal was obtained prior to it leaving the experimental facilities, after the animals' feed had been withheld for 12 hours. Both the hot carcass weight and the government grade are a matter of procedure. The only arrangement that had to be made was for the ear tag to remain with the carcass. This was done by cutting the ear tag out of the ear at slaughter and pinning it in the body cavity of the gutted carcass.

Approximately one week later, while the carcasses were still in the cooler, the rib eye and fat cover measurements were taken. This was done by taking the right side and dividing the quarters between the 11th and 12th ribs. A transparent plastic grid with 2.54 cm spacings was then placed over the loin eye (<u>longissmus</u>

dorsi) and a measurement taken. The fat cover measurements were taken by obtaining the length of the loin eye from the back bone down the side and then taking fat measurements at one-quarter, one-half, and three-quarters of this distance.

(d) Digestibility Trial

One animal from each ration group was retained at the conclusion of the feeding study to facilitate a digestibility trial. These animals were fed 6.8 kilograms of their respective rations and 32 grams of chromic oxide in capsulated form. Fecal samples were collected each day and chromic oxide determinations were made. A balling gun was used to administer the capsules to the animals. Unfortunately two steers had to be shipped as they would not adapt to the procedure used. Because of the reduced number of animals, the digestion trial was repeated, with the same animals being used to test different rations. The steers received the Cr_2O_3 for 17 consecutive days, with fecal collections being taken for the last 7 days. The animals were given the marker each day at 9 a.m., and the fecal collections were done at 4 p.m.

The procedure used in the chromic oxide determination was as follows:

1 to 2 gm of feed or feces were ashed in a 75 ml nickel crucible at about 600°C. After cooling, approximately 1 gm of Na_2O_2 was added, mixed well with the ash by swirling the crucible, and the mixture fused at gentle heat until liquid. The heating was continued for about five minutes at a low red heat, swirling the crucible occasionally. When cold, the crucible was placed in a 500 ml beaker and cold distilled water was added to dissolve the residue. The solution was left standing for five to ten minutes, then transferred into a beaker. The crucible was washed thoroughly with hot distilled water. The solution was left standing in the beaker for about thirty minutes, then filtered into an Erlenmeyer flask and the residue was washed with warm distilled water. The filtrate was transferred into a 500 ml volumetric flask and made up to volume with distilled water. Light transmission was measured with a photoelectric colorimeter, using a 440 mu filter, and with distilled water as a blank. The amount of Cr_2O_3 was determined from a standard calibration curve. (Schurch et al, 1950)

D. RESULTS AND DISCUSSION

(a) Feeding Trial

Average Daily Gains

Average daily gains were calculated on a basis of 14-day intervals. This method is less arbitrary than calculating on a daily basis. Table V indicates that the largest average daily gains were obtained with Ration No. 12 (10% chopped hay, 81% steam-rolled barley and 9% soybean oil meal). Feed costs and feed efficiencies must be considered in order to establish the most practical ration.

Feed Consumption

Ration No. 12 had the lowest feed consumption in the 227-272 kg range and Ration No. 13 had the lowest feed consumption in the 272-318 kg range.

Ration Cost per Kilogram of Gain

The cost of each ration, and the kilograms of feed required for one kilogram of gain, are the two main points to consider in calculating the cost per kilogram of gain. As the experiment progressed, the cost of one kilogram of gain increased, with the majority of animals requiring greater intakes to put on a kilogram of gain. Ration costs, feed conversions, and ration cost per kilogram of gain, are given in Table V.

Growth Curves

Growth curves for all the rations are not included; however, a representative curve pertaining to Ration No. 1 is given in Figure I. Similar growth curves were obtained on all rations, with no major changes due to the over-wintering period or ration adjustments that were made.

Ration Analyses

The proximate analyses of the rations used is given in Table VI.

Feedlot Application

Feed efficiencies were high and gains high enough for all rations to demonstrate that practical application of all rations to feedlot operations is possible.

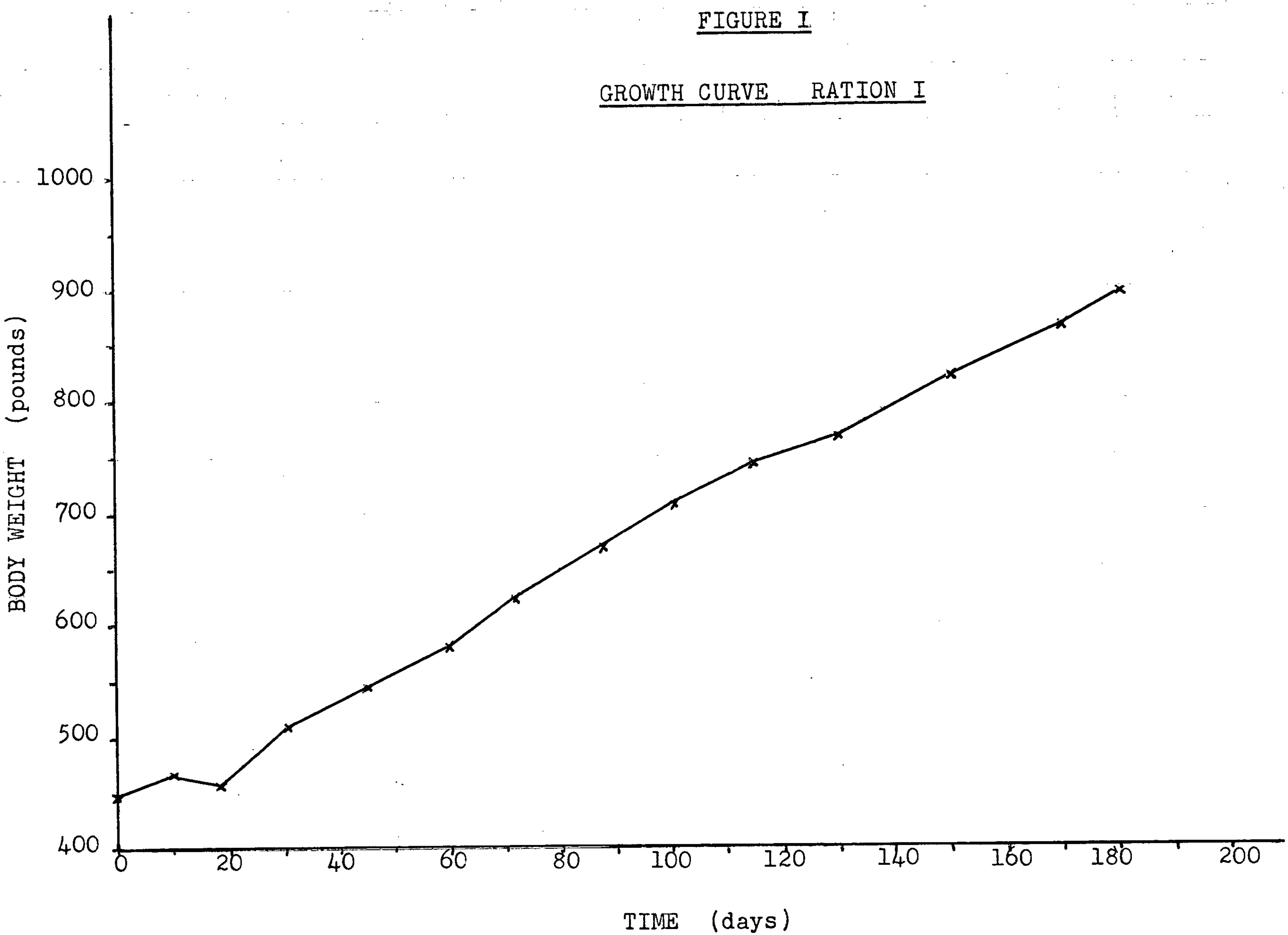


FIGURE I
GROWTH CURVE RATION I
BODY WEIGHT (pounds)
1000
900
800
700
600
500
400
0
20
40
60
80
100
120
140
160
180
200
TIME (days)

STUDY I

TABLE V

AVERAGE DAILY GAINS AND FEED EFFICIENCIES

(Nov. 21 - May 15) 175 days

Ration No.	Major Constituents %	Overall A.D.G.[1] (kg)	(lbs)	Overall F.E.[2]	Average Feed Cost per 45.45 kg gain
1	10LS/78B	1.17	2.59	6.34	$19.08
2	10S/78B	1.21	2.68	6.11	18.39
3	25S/60B	1.08	2.38	6.39	19.17
4	40S/42B	1.04	2.30	7.04	21.06
5	10S/61B/15Be	1.15	2.53	6.80	21.42
6	25S/47B/11Be	1.02	2.25	7.10	22.13
7	40S/33B/8Be	1.05	2.33	6.65	20.38
8	10S/82W	1.14	2.52	5.70	18.73
9	25S/63W	1.11	2.45	6.15	19.75
10	40S/44W	1.04	2.30	6.19	19.53
11	10LH/81B	1.24	2.73	5.05	14.90
12	10H/81B	1.31	2.89	5.18	15.29
13	25H/69B	1.18	2.61	5.43	15.18
14	40H/56B	1.15	2.53	6.70	17.81
15	10H/64B/16Be	1.25	2.76	5.11	15.81
16	25H/51B/13Be	1.24	2.73	5.78	16.89
17	40H/44B/11Be	1.26	2.78	6.12	16.84
18	10H/86W	1.15	2.53	6.18	16.55
19	25H/73W	1.18	2.61	5.61	16.74
20	40H/60W	1.18	2.60	5.51	16.65

[1] A.D.G. - Average Daily Gain = $\frac{\text{Final Wt. - Initial Wt.}}{\text{175 days}}$

[2] F.E. - Feed Efficiency (kg feed/kg of gain)

L - denotes long form as against chopped

H - Hay
B - Barley
W - Wheat
S - Straw
Be - Beet Pulp

TABLE VI

PROXIMATE ANALYSES OF RATIONS
(dry matter basis)

Ration No.	Major Constituents %	Crude Protein %	Crude Fibre %	Crude Fat %	Ash %	Ca %	N.F.E.[1] %	G.E.[2] KCal/kg
1	10LS/78B	16.22	10.67	2.49	2.23	.06	56.06	4.624
2	10S/78B	16.22	10.69	2.49	3.23	.06	67.32	4.323
3	25S/60B	16.01	17.84	2.41	4.15	.09	59.46	4.592
4	40S/42B	15.95	25.01	2.31	5.07	.12	51.6	4.550
5	10S/61B/15Be	16.17	13.24	2.18	4.19	.11	64.14	4.643
6	25S/47B/11Be	16.14	19.81	2.15	4.89	.12	56.91	4.604
7	40S/33B/8Be	15.9	26.39	2.13	6.70	.14	43.90	4.567
8	10S/82W	15.71	9.89	2.24	3.24	.23	57.51	4.203
9	25S/63W	15.61	17.60	2.32	4.86	.23	55.69	4.013
10	40S/44W	16.80	25.32	2.08	6.06	.23	51.42	4.857
11	10LH/81B	16.19	8.74	2.49	2.54	.19	57.16	4.596
12	10H/81B	16.19	8.74	2.49	2.54	.19	57.16	4.596
13	25H/69B	15.42	13.02	2.41	2.39	.39	51.14	4.524
14	40H/56B	14.83	17.28	2.32	2.25	.60	49.78	4.451
15	10H/64B/16Be	16.12	11.40	2.17	3.54	.23	54.64	4.616
16	25H/51B/13Be	15.42	15.28	2.13	3.24	.43	51.37	4.541
17	40H/44B/11Be	14.70	19.14	2.09	2.94	.63	48.13	4.466
18	10H/86W	15.43	7.44	2.04	2.54	.17	58.01	4.216
19	25H/73W	13.97	11.89	2.02	2.38	.46	55.27	3.858
20	40H/60W	14.31	16.38	2.01	2.25	.71	50.34	3.907

[1] Nitrogen Free Extract

[2] Gross Energy

L - denotes long form as against chopped

H - Hay
B - Barley
W - Wheat
S - Straw
Be - Beet Pulp

(b) Carcass Trial

The results of the carcass information are given in Table VII. Of the animals, 97 graded "choice", and 3 graded "good". The overall averages were:

	Mean	Range
Shipping Weight	473 kg	389-541 kg
Dressed Weight	274 kg	240-317 kg
Dressing %	57.8%	54.8 - 61.9%
Rib Eye Measurement	67.72 sq cm	43.53-82.23 sq cm
Fat Cover Average	2.03 cm	1.27 - 3.30 cm

The fact that 97% of the animals involved in this study still managed to fall within one grade classification under the Canada Department of Agriculture Beef Carcass Grading, prior to September 5, 1972, points out the apparent inaccuracy of the system. It appears that there is little or no correlation between the lean meat in kilograms in a carcass and the grade obtained. Only one animal of the 3 that graded "good" affected the range figures at all, and it did not affect them adversely. This carcass had both the least fat cover and the largest rib eye measurement.

TABLE VII

PEN AVERAGE DRESSING PERCENTAGES, RIB EYE AND FAT COVER MEASUREMENTS

Ration No.	Major Constituents %	Dressing %	Rib Eye sq cm	Rib Eye sq inches	Fat Cover cm	Fat Cover inches
1	10LS/78B	57.7	61.2	9.5	2.28	.9
2	10S/78B	58.3	66.4	10.3	2.03	.8
3	25S/60B	56.9	66.4	10.3	1.77	.7
4	40S/42B	55.8	67.7	10.5	1.52	.6
5	10S/61B/15Be	57.8	70.9	11.0	2.28	.9
6	25S/47B/11Be	57.7	69.0	10.7	2.03	.8
7	40S/33B/8Be	56.5	66.4	10.3	2.03	.8
8	10S/82W	58.4	66.4	10.3	2.03	.8
9	25S/63W	57.5	74.1	11.5	1.77	.7
10	40S/44W	57.5	69.6	10.8	1.77	.7
11	10LH/81B	57.8	69.6	10.8	1.77	.7
12	10H/81B	58.7	64.5	10.0	2.28	.9
13	25H/69B	57.6	69.6	10.8	2.03	.8
14	40H/56B	58.1	72.2	11.2	1.77	.7
15	10H/64B/16Be	58.1	69.0	10.7	2.28	.9
16	25H/51B/13Be	58.2	67.7	10.5	2.28	.9
17	40H/44B/11Be	57.9	67.7	10.5	2.03	.8
18	10H/86W	59.2	70.9	11.0	2.28	.9
19	25H/73W	59.4	67.7	10.5	2.28	.9
20	40H/60W	58.5	66.4	10.3	2.03	.8

L - denotes long form as against chopped
H - Hay
B - Barley
W - Wheat
S - Straw
Be - Beet Pulp

It should be noted that the animals that consumed the rations having 40% roughage (4, 7, 10, 14, 17, 20) had less than average fat cover. Those that were offered rations 4, 7, 10 (40% straw), had a rib eye measurement of less than the average (Table VII). Rations 14, 17, 20, contained 40% hay.

(c) <u>Digestibility Trial</u>

There seems to be an indication that the high roughage rations (40%), i.e. rations 4, 7, 10, 14, 17, 20, had a lower dry matter digestibility. The results of the trial are given in Table VIII. This trial encountered numerous problems which explain why there were not two animals used on each ration as shown in Table VIII.

STUDY I

TABLE VIII

AVERAGE DRY MATTER DIGESTIBILITIES

Ration No.	Major Constituents %	Animal 1	Animal 2	Average Dry Matter Digestibility %
1	10LS/78B	82.9	77.8	80.35
2	10S/78B	79.2	69.4	74.3
3	25S/60B	75.2	74.2	74.7
4	40S/42B	69.9	-	69.9
5	10S/61B/15Be	73.12	74.16	73.64
6	25S/47B/11Be	73.87	71.04	72.45
7	40S/33B/8Be	75.98	81.76	78.87
8	10S/82W	72.09	-	72.09
9	25S/63W	#64.27	75.67	69.97
10	40S/44W	75.65	75.70	75.67
11	10LH/81B	74.41	74.24	74.32
12	10H/81B	71.61	71.39	71.50
13	25H/69B	72.04	#61.61	66.82
14	40H/56B	69.09	69.90	69.49
15	10H/64B/16Be	74.95	75.24	75.09
16	25H/51B/13Be	72.45	-	72.45
17	40H/44B/11Be	70.92	72.60	71.76
18	10H/86W	79.43	81.28	80.35
19	25H/73W	80.52	-	80.52
20	40H/60W	#64.91	76.08	70.49

Poor collection

L - denotes long form as against chopped
B - Barley
S - Straw

H - Hay
W - Wheat
Be - Beet Pulp

STUDY II

THE EFFECT OF VARIOUS FEED GRAINS
ON THE GROWTH PATTERNS
OF GROWING AND FATTENING STEERS

A. INTRODUCTION

Study II involved a feeding trial using Hereford steers and rations which varied in content, with barley, wheat, and corn, being compared.

Two of the major considerations in determining what constituents will make up a concentrate in any particular area are economics and cost. For example, corn is an expensive feed constituent in the lower Fraser Valley and is, therefore, not used to any extent in local commercial feedlots. However, it can not be ignored from a research point of view simply because of cost.

Canada's grain situation is changing rapidly because of world trade and ever-expanding markets. If Canada is to take full advantage of these expanding markets, research must be done with grains produced both here and elsewhere so that the relative value of Canadian grains can be established reasonably accurately.

Energy concentration and intake determine the ability of a feed grain to produce rapid and economical gains. On a pound for pound basis, high-energy feed grains will produce more beef at lower costs than do low-energy feeds. Therefore, in the discussion and results part of this study, a close look will be taken at the energy evaluation of the six rations used.

Also, it is recognized that a shift in the geographical setting of this study would completely alter or change the economic appraisal of these results. However, the primary aim of this study was to compare the value of corn, barley and wheat as basal grains, and to investigate the possible value of mixing the grains in various proportions. The criteria considered were, average daily gain, feed efficiency, cost per kilogram of gain, carcass grade, and dressing percentage.

A secondary consideration in the study was the economic feasibility of any one ration compared to the others. Also considered in this study was the carcass evaluation in terms of use to the consumer.

B. LITERATURE REVIEW

When comparing the feeding values of different grains, one very important characteristic to examine is the energy content. Corn, barley, and wheat, are all relatively high in energy content. However, barley contains about 5% less net energy than does wheat or corn. The generalized breakdown of average energy utilization in a feed for ruminants is given in Figure II.

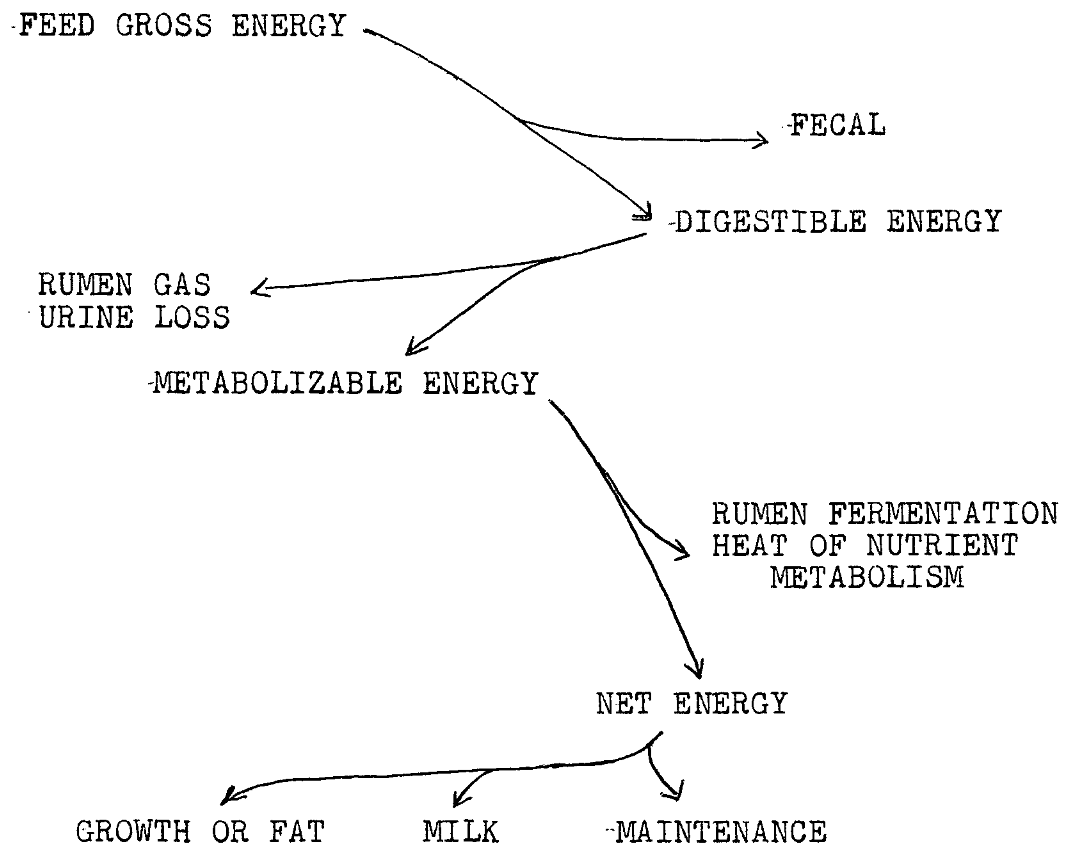
There are several systems for evaluating feeds on an energy basis, with the following systems being most widely used in North America:

1. Digestible Energy
2. T.D.N. or Total Digestible Nutrients
3. Net Energy-Maintenance and Production

Of the systems used in the past the most common was the Total Digestible Nutrient system (TDN). The Net Energy system was a refinement of the TDN system. By its definition, net energy refers to that part of the energy of the feed which is available to support maintenance, milk production or growth. It was an improvement over the TDN system and its use has permitted improvement in the feeding management of ruminants.

STUDY II FIGURE II

ENERGY RELATIONSHIPS



WT. GAIN	MILK	MAINTENANCE ENERGY	HEAT OF NUT. METAB.	RUMEN FERMEN-TATION	METHANE LOSS	URINE LOSS	FECES

<---- GROSS ENERGY -->
<---- DIGESTIBLE ENERGY ------------------------------>
<---- METABOLIZABLE ENERGY ------------->
<---- NET ENERGY ------->
<-- NE_p ----><--- NE_m -->

NE_p - Net Energy Production
NE_m - Net Energy Maintenance

Source: Cardon (1970)

Net energy will be used for all calculations throughout this paper. This net energy system used in the growing and finishing phases of beef cattle was introduced by Lofgreen et al in 1963. This system separates the requirements for maintenance from that for body weight gain, and expresses a net energy value of the feed for these two functions. NE_m represents the net energy requirement and the net energy content of the feed when used for maintenance. NE_g represents the net energy used for production of weight gain. Net energy for maintenance is established on the basis that NE_m requirement for both steers and heifers is equal to approximately 0.077 Mcals per unit of metabolic body size ($W^{0.75}$kg). The energy deposited in weight gain of steers (the NE_g requirement) is represented by the equation

$$NE_g = (52.72 \text{ gain} + 6.84 \text{ gain}^2) (W^{0.75}\text{kg}).$$

NE values are also useful in determining whether cattle have gained weight in accordance with expectations. When NE requirements are separated into maintenance and body weight gain, they do not vary when different roughage/concentrate ratios are fed, as do ME and TDN requirements.

The standard tables of Feed Composition NRC 1959, Morrison, 1956, indicated that corn was slightly superior to barley on a TDN or a calculated net energy basis. Many researchers noticed, however, that better gains and feed efficiency were obtained with barley. Hale et al (1962), reported that barley showed a 5% increase in daily gain, with a 8.7% decrease in feed required when compared to corn. Garrett et al (1964) re-evaluated barley and corn net energy values. Their results indicated that barley and corn, or a 50-50 mixture of these grains, are approximately equal in their net energy content. Therefore, there should be no reason for feeders to discriminate against corn as a source of energy when fed in a balanced ration.

The problem of describing the overall available energy value of feeds is somewhat the same as that of describing the nutritive worth of the protein complex. The worth of a feed grain as a source of protein quality is dependent on two factors, the total concentration of the proteins and the distribution of the amino acids making up the proteins. Since the body contains many different proteins having different amino acid relations, the usefulness of a feed grain depends, in part, on the purpose for which it is fed. For example, fewer amino acids are needed for maintenance than for rapid growth. The usefulness of the protein of a particular ration in meeting the animals' protein (nitrogen) needs is often referred to as its quality.

Although net energy values for corn have been estimated at several stations, there is still considerable lack of agreement. Vance et al (1972) theorized that this variation is due to a number of factors, including temperature or environment (Garrett et al 1964), the breed or sex of cattle (Hall et al 1968, Klosterman et al 1968), and the method of determining net energy. Also, there is still controversy regarding the associative effects of individual feeds in mixed rations. Blaxter et al (1964) concluded "that the net energy of a food determined by adding it to a basal diet is not constant but varies with the level of feeding adapted and the nature of the basal diet".

Grinding has long been recommended for corn grain in finishing rations. Recent feedlot research has suggested that whole shelled corn can be satisfactorily fed (Hixon et al 1969, Burkhardt et al 1969, McLaren et al 1970, Gerken et al 1971).

Corn and barley were used and compared in this feeding trial because of the indicated research and the world-wide recognition of corn or maize as a grain crop. Although it appears (FAO 1971) there will be less wheat available in the future for animal feeding or beef production, it was used and compared in this trial because of its use and recognition throughout the world as an important grain crop.

While carcass data were gathered in this study for comparison purposes between rations, it is also notable that a great deal of research is currently being done in Canada, especially with regard to the beef grading system used. The grading system in use in Canada during this study contains a great deal of mythology as does the merchandising of beef to the consumer. The current grading system does not accurately predict the quantity or quality of the lean meat within a carcass. The proposed new grading system (September 1972) will attempt to predict more accurately carcass value in light of recent research.

One example of the carcass research is the question of beef tenderness and bull meat. Pearson (1966) showed that tenderness is generally accepted as the most important single attribute contributing to the acceptability of beef. It has long been assumed that fatness, both external in the form of finish, and intra-muscular in the form of marbling, was related to tenderness. The question of prime importance was whether marbling and carcass fat are basic requisites for meat tenderness, or whether tenderness is primarily a function of animal age and other factors. In addition to animal age, the degree of carcass ageing requires specification. Martin _et al_ (1970) suggested that the entire relationship between tenderness and other quality factors, and marbling and fatness in relation to sex, ageing period, maturity, requires comprehensive evaluation. They thought this timely due to current trends toward slaughtering of younger cattle and increasing interest in yield grading for beef carcasses. Martin _et al_ (1970) concluded "Insofar as the population in the present study was concerned, finish or other fatness measurements were unrelated to tenderness, while variation in marbling explained only 9% of the variation in tenderness".

C. MATERIALS AND METHODS

(a) Feeding Trial

Experimental Design

The experimental animals were randomly allocated to twelve pens, five animals in each. Two pens were assigned to one of each of the six rations. The animals were slaughtered when they reached a live weight of 454-477 kilograms.

Experimental Animals

The experimental animals (63 Hereford steer calves) were obtained from the B.C. Livestock Producers' Co-operative Association at Merritt, B.C. and were selected on the basis of uniform body weights and conformation. The average weight of the animals on day 6 was 223.6 kilograms. The steers were all ear-tagged and allocated at random to pens, five animals in each.

Housing

Housing was the same as that described in Study I.

Initial Treatment and Feeding Procedure

On arrival at the experimental facilities (day 1), the animals were fed alfalfa-bermuda grass hay (long form). The animals were given injections of Provite[1] (1 cc.) (Vitamins A, D_2 and E), to prevent or correct any vitamin deficiencies, and Rea-Plex[2] (2 cc.) for prevention of infectious bovine rhinotracheitis.

The animals were ear-tagged and randomly assigned to pens. The hay diets continued through the adjustment period. The grain proportion was gradually increased and the roughage proportion was decreased until at the ration formulas (Table IX). These ration formulas were met on day 37. All steers were subcutaneously implanted with 36 milligrams of Diethylstilbestrol. DES was used because literature has indicated improved feed efficiencies and rates of gain.

Source: 1 Ayerst Laboratories, Division of Ayerst, McKenna & Harrison Limited, Montreal, Quebec.

2 Fort Dodge Laboratories Inc., Fort Dodge, Iowa.

STUDY II

TABLE IX

RATION COMPOSITION AND COSTS
(air dry basis)

Ration No.	Percentage of Composition	Cost/ 1000 kg	Cost/ ton
1	90 Wheat/10 Hay	$67.87	$61.70
2	90 Barley/10 Hay	57.97	52.70
3	90 Corn/10 Hay	94.60	86.00
4	74 Barley/16 Wheat/10 Hay	59.73	54.30
5	45 Barley/45 Wheat/10 Hay	62.92	57.20
6	74 Wheat/16 Barley/10 Hay	66.11	60.10

Note: All hay fed in chopped form.

Ration costs plus $ .04 per head per day for Vitamin-Mineral supplement.

In addition to the indicated ration each animal received .45 kg per day of the experimental Vitamin-Mineral supplement.

The daily feed procedure during the experiment involved feeding once per day, each morning. On days when the animals were to be weighed, feed was withheld one hour until weighing was completed. The animals were fed as much as they could consume in 24 hours.

Rations

Ration compositions and proximate analysis data are given in Tables IX and X. Protein and Vitamin-Mineral Premix composition are given in Table XI.

Weighing Procedure

Weighing was done bi-weekly. After being weighed a few times, the animals became accustomed to the procedure and the operation was done with a minimum of disturbance to the steers.

Ration Costs

Costs of all ration constituents are given in Table XII. Flaked corn was the most expensive constituent at $92.00 per ton. This cost was largely due to availability. Ration costs were again reasonably low considering location and size of experimental facilities. Table XII also gives other costs involved in the experiment.

STUDY II

TABLE X

PROXIMATE ANALYSES OF FEEDSTUFFS

Feedstuff	Moisture %	Protein %	Crude Fibre %	Ash %	Fat %	Energy Kcal/gm
Barley	13.0	11.3	8.4	2.7	3.1	4.228
Wheat	12.0	12.9	3.4	1.8	2.9	4.478
Corn	13.0	9.7	4.4	1.1	3.3	4.250
Hay	10.0	11.1	39.8	5.5	4.4	4.292
Vitamin-Mineral Supplement	10.0	10.7	7.0	19.0	4.5	3.331

STUDY II

TABLE XI

COMPOSITION OF EXPERIMENTAL PREMIX

Vitamin-Mineral Supplement

Vitamin A	-	140 gm (325,000 I.U. per gm)
Vitamin D	-	120 gm (80 million I.U. per lb)
$CuSO_4$	-	40 gm
$CoSO_4$	-	40 gm
$MnSO_4$	-	600 gm
$ZnSO_4$	-	1000 gm
Prodine	-	36 gm (170 mg Iodine per gm)

Experimental Premix

(fed at .45 kg per head per day)

Vitamin Mix as above	-	4.5 kg
Limestone	-	63.6 kg
Dicalcium Phosphate	-	45.4 kg
Salt	-	72.7 kg
Barley	-	618.1 kg
Shorts	-	90.8 kg
Tallow	-	13.6 kg
Total		909 kg

STUDY II

TABLE XII

COSTS OF MATERIALS

Steam Rolled Barley	$ 60.50/ton	(metric)	($55.00/ton	(Short))		
Flaked Corn	101.20 "	"	($92.00	"	"	)
Dry Rolled Wheat	71.50 "	"	($65.00	"	"	)
Experimental Premix	91.30 "	"	($83.00	"	"	)
Grass Hay	35.20 "	"	($32.00	"	"	)
Other Costs						
Salt Blocks	83.60/ton	(metric)	($76.00/ton	(Short))		
Diethylstil-bestrol implants	32.00					
Drugs	150.00					
Shavings - 4 units	12.00					
Ear Tags	Re-usable					
Cattle						
63 head			$12,255.15.			

(b) Management Procedures

Adaption

The animals adapted exceedingly well to the rations and the experimental environment. All were shipped directly from range conditions and, immediately upon arrival at the experimental facilities, were started on solid food. After an incubation period of 10-14 days, there was an occurrence of some shipping fever symptoms but these were effectively treated with antibiotics.

Animal Health

During the initial adjustment of the animals to the rations, one steer died (Nov. 29) due to bloat. The only other major health problem was the death of a second steer on March 13th. The cause of death was unknown. However, this time the suspected cause was malignant edema. At this time, on March 16th, all remaining steers were treated with 5 cc intramuscularly of "Clostridium chauvei-septicum pasteurella bacterin"[1]. The cost of this treatment was approximately $10.00 for the entire group.

Source: 1 Norden Laboratories, Lincoln, Nebraska.

Ration Preparation

All hay was fed in the chopped form and the various constituents of the ration were not mixed prior to feeding but simply weighed out and placed in the feed trough. No adjustments were made in the rations aside from minor changes within batches of grain.

(c) Carcass Trial

The animals were slaughtered when they reached a live weight of 454-477 kilograms. The following data were collected:

1. Shipping Weight
2. Hot Carcass Weight
3. Government Grade.

The shipping weight of each animal was obtained prior to it leaving the experimental facilities. Both the hot carcass weight and the government grade are a matter of procedure. The only arrangement that had to be made was for the ear-tag to remain with the carcass.

D. RESULTS AND DISCUSSION

(a) Feeding Trial

Average Daily Gains

Average daily gains were calculated on a basis of 14-day intervals throughout the 151 day trial. The largest average daily gains were obtained with Ration No. 6 (74% Wheat/16% Barley/10% Hay) in Pen No. 11. However, since duplicates were run, it is possible to obtain an average of two separate pens of steers on each ration. The average results are given in Table XIII. It is interesting that both Ration No. 1 and Ration No. 6 obtained over-all average daily gains of 1.32 kilograms.

Feed Consumption

Daily feed consumption per pen was recorded throughout the experiment to allow calculation of over-all feed efficiencies as shown in Tables XIV and XV. In Table XIII it can be seen that Ration No. 1 was the most efficient ration (90% Wheat, 10% Chopped Hay).

Ration Cost per Kilogram of Gain

In Table XIII it can be seen that Ration No. 2 (90% Barley/10% Hay) had the lowest cost per 45.45 kilogram of gain at $16.50.

Growth Data

Growth curves are not presented because uniform growth curves were obtained on all rations. However, growth data for the entire trial is given in Table XIV. Table XV also presents the feed efficiencies calculated for the entire trial.

Ration Analyses

Proximate analyses data for the rations used is given in Table XVI.

STUDY II

TABLE XIII

AVERAGE DAILY GAINS AND FEED EFFICIENCIES

Ration No.	Major Constituents %	Overall A.D.G.[1] (kg)	(lbs)	Overall F.E.[2]	Average Feed Cost per 45.45 kg gain
1	90W/10H	1.32	2.92	5.55	$17.13
2	90B/10H	1.27	2.81	6.26	16.50
3	90C/10H	1.20	2.65	6.01	25.88
4	74B/16W/10H	1.30	2.88	6.33	17.20
5	45B/45W/10H	1.16	2.56	6.24	17.86
6	74W/16B/10H	1.32	2.92	5.83	17.54

[1] A.D.G. - Average Daily Gain = $\frac{\text{Final Wt. - Initial Wt.}}{\text{151 days}}$

[2] F.E. - Feed Efficiency (kg feed/kg of gain)

W - Wheat
H - Hay
B - Barley
C - Corn

STUDY II

TABLE XIV

GROWTH DATA

AVERAGE DAILY GAINS IN PERIODS OF TWO WEEKS
(kilograms)

	Period 1	2	3	4	5	6	7	8	9	10	11
Pen 1	.82	1.50	1.63	1.48	1.38	1.44	1.53	1.50	1.00	1.58	1.23
2	.72	1.51	1.59	1.90	.57	1.20	1.16	1.62	1.38	1.12	1.27
3	.52	1.59	1.96	1.46	1.06	1.07	1.45	1.55	1.08	1.30	1.03
4	.80	1.65	1.42	1.57	.97	1.12	1.73	1.40	.89	1.51	1.08
5	.38	1.32	1.51	1.55	1.39	.09	1.25	1.27	1.29	1.41	1.27
6	.62	1.63	1.90	1.56	1.22	1.24	-	1.18	.92	1.00	.52
7	.55	1.73	1.74	1.80	1.12	1.62	.84	1.40	1.35	1.35	1.06
8	.90	1.72	1.73	1.68	1.02	1.03	1.29	1.27	1.50	1.23	0.0
9	.80	1.62	1.35	1.41	1.06	1.36	.80	1.59	1.06	1.13	.52
10	.81	1.64	1.47	1.35	1.15	1.33	.89	1.09	1.08	1.25	.40
11	.79	1.75	1.85	2.00	1.00	1.63	.90	1.42	1.50	1.51	1.28
12	.79	1.84	1.50	1.23	1.23	1.22	1.13	1.10	1.12	1.12	1.18

STUDY II

TABLE XV

GROWTH DATA

Feed Efficiency - Kilograms of Feed/Kilograms of Gain

	Period 1	2	3	4	5	6	7	8	9	10	11
Pen 1	5.43	3.74	4.14	4.80	5.84	5.69	5.48	5.80	8.86	5.73	7.1
2	6.16	3.69	4.24	3.61	13.8	6.39	6.33	4.85	5.96	7.07	6.07
3	9.38	3.80	3.82	5.46	7.66	7.59	6.07	6.06	8.65	7.63	10.1
4	6.12	3.65	5.06	4.74	8.38	7.24	5.62	6.13	9.38	6.11	9.2
5	11.5	3.92	4.27	4.71	5.80	7.85	6.15	6.16	6.02	5.89	6.6
6	7.91	3.71	3.80	4.81	6.83	6.49	-	5.21	8.35	8.04	13.4
7	8.94	3.48	4.33	4.69	8.27	6.49	10.26	6.14	6.85	7.37	9.8
8	5.42	3.51	4.19	4.77	8.35	8.37	7.0	7.46	6.45	8.06	-
9	6.12	3.72	5.26	4.96	7.01	5.58	9.4	4.90	7.25	7.34	15.0
10	6.03	3.68	4.80	5.30	6.47	5.66	8.58	7.26	7.04	6.49	-
11	6.22	3.46	3.92	4.0	8.80	5.27	8.96	5.72	5.88	5.98	7.4
12	6.22	3.29	4.80	6.38	6.95	6.83	6.91	7.14	7.13	7.08	6.9

STUDY II

TABLE XVI

PROXIMATE ANALYSES OF RATIONS

Ration No.	Major Constituents %	Moisture %	Crude Protein %	Crude Fibre %	Crude Fat %	Ash %	Gross Energy Kcal/gm
1	90W/10H	11.8	12.7	7.04	3.05	2.17	4.45
2	90B/10H	12.7	11.27	11.54	3.23	2.98	4.23
3	90C/10H	12.7	9.83	7.94	3.41	1.54	4.25
4	74B/16W/10H	12.54	11.52	10.73	3.19	2.82	4.27
5	45B/45W/10H	12.25	11.98	9.29	3.13	2.57	4.34
6	74W/16B/10H	11.96	12.44	7.83	3.07	2.31	4.41

W - Wheat
H - Hay
B - Barley
C - Corn

Energy

As discussed in the introduction of this study, it is possible theoretically to predict weight gains if energy intake is known. The NE_m and NE_g for growing and finishing steers are given in Table XVII. The net energy concentration required of beef cattle rations (dry matter basis) for finishing calves (250-450 kg body weight) is 1.17 Mcal/kg of ration. Table XVIII shows the component parts of those feeds used in the various rations tested.

The theoretical feed consumption of a 300 kg and 400 kg steer are given in Table XIX. By using projected intakes and feed compositions from Nutrient Requirements of Beef Cattle (1970), the theoretical weight gains were calculated. Table XX shows the results obtained. It can be seen in this Table that the actual results were very accurately predicted. It was noted, however, that the amounts of feed consumed by each animal were greater than the theoretical value used.

STUDY II

TABLE XVII

NET ENERGY REQUIREMENTS OF GROWING AND FINISHING BEEF CATTLE (Mcal/animal/day)

Body Weight (kg)	100	200	300#	350	400	450#	500
NE_m required	2.43	4.10	5.55	6.24	6.89	7.52	8.14
Daily Gain (kg)	NE gain required						
Steers							
0.1	0.17	0.28	0.39	0.43	0.48	0.52	0.56
0.2	0.34	0.57	0.78	0.88	0.97	1.06	1.14
0.3	0.52	0.87	1.18	1.33	1.47	1.61	1.84
0.4	0.70	1.18	1.60	1.80	1.99	2.17	2.34
0.5	0.89	1.49	2.02	2.27	2.51	2.74	2.97
0.6	1.08	1.81	2.46	2.76	3.05	3.33	3.60
0.7	1.27	2.14	2.90	3.26	3.60	3.93	4.25
0.8	1.47	2.47	3.36	3.77	4.17	4.55	4.92
0.9	1.67	2.81	3.82	4.29	4.74	5.18	5.60
1.0	1.88	3.16	4.29	4.82	5.33	5.82	6.29
1.1	2.09	3.52	4.78	5.37	5.93	6.47	7.00
1.2	2.31	3.88	5.27	5.92	6.55	7.14	7.73
1.3	2.53	4.26	5.77	6.49	7.17	7.82	8.46
1.4	2.76	4.63	6.29	7.06	7.81	8.52	9.22
1.5	2.99	5.02	6.81	7.65	8.46	9.23	9.98

Source: Nutrient Requirements of Beef Cattle (1970)

STUDY II

TABLE XVIII

NET ENERGY AND DIGESTIBLE PROTEIN VALUES OF FEEDS USED IN RATIONS

	NE_m (Mcal/kg)	NE_g (Mcal/kg)	Digestible Protein %
Wheat	2.16	1.42	9.2
Barley	1.93	1.29	8.2
Corn	2.28	1.48	7.6
Grass Hay	1.26	.62	5.7
Experimental Premix	1.40	.81	7.0

Source: Nutrient Requirements of Beef Cattle (1970)

STUDY II

TABLE XIX

THEORETICAL FEED CONSUMPTION

300 kg steer	-	requires 5.55 Mcal for NE_m
	-	consumes 2.4 kg dry matter/100 kg of body weight, or, in this case, 7.2 kg dry matter/day
		of
		6.07 kg - concentrate
		.67 kg - roughage
		.45 kg - Experimental Premix
400 kg steer	-	requires 7.52 Mcal for NE_m
	-	consumes 2.1 kg dry matter/100 kg of body weight or 9.4 kg dry matter/day
		of
		8.05 kg - concentrate
		.89 kg - roughage
		.45 kg - Experimental Premix

Source: Nutrient Requirements of Beef Cattle (1970)

STUDY II

TABLE XX

THEORETICAL VERSUS ACTUAL GAINS

Ration No.	Major Constituents %	Theoretical Gain (kg)	Actual Gain (kg)	Difference Actual from Theoretical Gains (kg)
1	90W/10H	1.25	1.24	+ .01
2	90B/10H	1.29	1.39	- .10
3	90C/10H	1.53	1.42	+ .11
4	74B/16W/10H	1.47	1.57	- .10
5	45B/45W/10H	1.28	1.20	+ .08
6	74W/16B/10H	1.51	1.61	- .10

W - Wheat
H - Hay
B - Barley
C - Corn

The need of every living cell for protein is well established. Thus, animals depleted in protein are known to be less resistant to a number of diseases, and to have a lower ability to recover quickly or to develop immunity to diseases, than do properly nourished animals. In addition, the enzymes which digest the feed and help in its utilization in the body, as well as the vital hormones which regulate body reactions, are protein in nature. The quality of a protein depends on such factors as amino acid make-up, its digestibility, and the amount of non-protein nitrogen it contains.

The protein requirements given in Table XXI are those for finishing steer calves and are based on minimal needs for optimum production. Some research has indicated that feed intake increases and overall performance improves when preformed supplemental protein replaces supplemental non-protein nitrogen in cattle rations. Thus feeding more than the recommended level may be economically feasible.

Protein requirements are expressed on the basis of both total and digestible protein. Ration digestible protein percent (y) is expressed as a function of ration total protein percent (x) by the equation:

$$y = 0.877\ x \text{ minus } 2.64$$

(b) <u>Carcass Trial</u>

The results of the carcass trial are given in Table XXII.

When compared with the carcass trial from Study I, it can be seen that while the dressing percentage was essentially the same, the average shipping weight was lighter. This can be partially explained by the dropping market at shipping time, combined with the fact that the cattle were one month behind the cycle of the previous year. Those carcasses that were graded down were done so on a conformation basis. This was a reflection of the general conformation and uniformity of the entire group as compared to Study I.

STUDY II

TABLE XXI

PROTEIN REQUIREMENTS FOR FINISHING STEERS

Body Weight kg	A.D.G. kg	Daily Dry Matter kg	Total Protein kg	Dig. Protein kg	Calcium gm	Phos- phorus gm	Caro- tene mg	Vit. A (thousands) I.U.
150	.90	3.5	.45	.30	21	15	19.5	7.8
200	1.00	5.0	.61	.41	23	17	27.5	11.0
300	1.10	7.1	.87	.58	26	19	39.5	15.8
400	1.10	8.8	.98	.62	25	20	49.0	19.6
450	1.05	9.4	1.04	.67	21	21	52.0	20.8

Source: Nutrient Requirements of Beef Cattle (1970)

STUDY II

TABLE XXII

RATION AVERAGE DRESSING PERCENTAGES

Ration No.	Major Constituents %	Shipping Wt. kg	Dressed Wt. kg	Dressing %
1	90W/10H	461	265	57.5
2	90B/10H	440	253	57.4
3	90C/10H	433	249	57.6
4	74B/16W/10H	453	260	57.4
5	45B/45W/10H	448	258	57.6
6	74W/16B/10H	457	263	57.4

W - Wheat
H - Hay
B - Barley
C - Corn

SUMMARY AND CONCLUSIONS

STUDY I

The effects of the roughage levels with the concentrate sources on the daily weight gains, feed conversion efficiencies and costs, can be summarized by rating the efficiency of each ration when based on:

1. Average daily gains
2. Feed conversion efficiencies
3. Cost per kilogram of gain
4. Cost per ton of feed.

All rations used in this study could be applied to commercial feedlot operations. Gains were good on all rations and costs were low enough to result in medium to excellent gains at reasonable prices with digestible disturbances at a minimum.

This study illustrated the advantage in feeding rations containing a high concentrate to roughage ratio to finishing beef steers. Performance in terms of average daily gain, rate of gain, and feed efficiency, was superior in those steers receiving a high concentrate to roughage ratio and decreased as concentrates decreased and roughages increased. This decrease in production can be attributed to a lowering of digestible energy content, an increase in fibre content, an increase in bulk, and consequently, a reduction in the rate of passage of feed through the animal as roughage percentage increased.

In the final analysis, the prices of concentrates and roughages in relation to the performance expected from them will determine what types and proportions to use. However, it appears that in commercial feedlots roughage levels would seldom rise above 10%. This generalization will be dealt with further in this summary.

STUDY II

The effects of the cereal content on the daily weight gains, feed conversion efficiencies and costs, can be summarized by rating the efficiency of each ration when based on:

1. Average daily gains
2. Feed conversion efficiencies
3. Cost per kilogram of gain
4. Cost per ton of feed.

All rations used in this study could be applied to commercial feedlot operations when judged by average daily gain and feed efficiency. However, the corn ration must be excluded when one considers cost/kg of gain. As mentioned earlier however, this cost situation may be, in fact, to the advantage of corn in other areas and act as a detriment to either barley or wheat.

In the final analysis of Study II, the prices of the various cereals in relation to the performance expected from them will determine what types and proportions to use. It appears that here in the Fraser Valley, however, the corn and wheat rations would not be as economically feasible as would a barley-orientated ration. The largest feed-lot in the Fraser Valley is currently feeding a ration based on barley with corn silage added in varying amounts, depending on stage of finish of animals.

GENERAL CONCLUSIONS

Many very important developments have changed feedlot operations in Canada during the course of these studies.

As pointed out by such organizations as the Food and Agriculture Organization of the United Nations, our world population is increasing rapidly. Accompanying this is an increase in the per capita intake of beef. An earlier generalization that most commercial feedlots would not feed more than 10% roughage may not be true in the not too distant future. At that time we may have to change our cattle so they can utilize waste material right up to market weight. This is assuming that grains will have to be used more efficiently by other animals and, therefore, will not be available in such great quantities for finishing beef cattle.

In September of 1972, the beef carcass grading system in Canada was changed. The main benefit of the new grading system, which came into effect on September 5th, is that it will make possible a more accurate description of carcasses from the point of view of both quality and quantity. It will give consumers a chance to indicate the type of carcass that is most in demand, and this could result in leaner carcasses. Quality grading under the new system will be more accurate than under the old because by knife-ribbing the carcass, the grader is able to appraise a cross-section of the lean meat. Quantity measurements will also be more accurate. Research has shown a close correlation between the thickness of fat at the 11th rib and the percentage of lean meat in the entire carcass. Graders will measure the fat thickness to one-tenth of an inch and classify the carcass in the appropriate fat level within the quality grade. Looking back to the carcass information in Study I, it is seen that fat cover ranged from 0.5 inches to 1.3 inches, yet 97% of the carcasses fell within one grade. This ambiquity will not happen within the new grading system.

Producers should benefit from the new system to the extent that they are able to produce the type of carcass which commands a premium price on the market. Everyone from the producer to the retailer will have a much more precise system for identifying and serving consumer demand. In little more than two months the new grading system is doing what it set out to do--the carcasses with high retail yield are bringing more money right through the marketing train, and the ones which require a lot of trimming and throw-away are being discounted right through.

Long and tall cattle of all classes are in strong demand. There is now more of a demand for big growthy yearlings to go into feedlots. There will be a strong demand for long and tall bulls. Exotic cross-breds are selling at the auctions for premiums both as feeders and slaughter animals. Anyone with documented growth and gainability in breeding stock will find ready markets.

These new grades call for great changes in both the feeding and breeding of cattle, and this will be both difficult and expensive for some people to learn. Cattle bred and fed as they were in both Study I and II will not be suitable for the future market, or at least not as acceptable as they were in the past. This new system will allow a feeder to capitalize to a greater extent on the values of hybrid vigour as obtained in crossbreeding. The feeder has also had the hormone DES removed from the list of drugs allowed. This will lower feed efficiencies in general and, as a result, increase the cost of producing a pound of beef. The pollution-conscious public, aside from approving of removal of synthetics from food, is also applying pressure to the commercial feeder regarding environmental pollution and waste disposal.

Recent research in feeding will undoubtedly be helpful to the commercial feeder. However, it is only one of a long list of changes confronting him -

new beef grading standards,
rise in beef consumption,
new beef marketing systems,
pollution controls,
management research,
large selection of new breeds,
hybrid vigour,
better transportation facilities and methods,
changing world markets,
synthetic meat.

While many of the general conclusions discussed here do not seem relevant to these studies, all changes currently being made in the industry must be considered because they affect further research in the future. The field of beef cattle feeding research is daily becoming more complex and interesting.

BIBLIOGRAPHY

1. Association of Official Agricultural Chemists (1960). Official Methods of Analysis. 9th edition. Washington, D.C.

2. Beeson, W.M. and Perry, T.W. (1952). Balancing the Nutrition Deficiencies of Roughages for Beef Steers. J. Anim. Sci. 11:501-515.

3. Blaxter, K.L. and Wainman, F.W. (1964). The Utilization of the Energy of Different Rations by Sheep and Cattle for Maintenance and for Fattening. J. Agr. Res. 63:113.

4. Bradley, N.W. (1958). An Evaluation of Chromic Oxide as an Indicator for Determining Digestibility of Beef Cattle Rations. Ph.D. thesis, University of Illinois, Urbana.

5. Burkhardt, J.D., Embry, L.B. and Luther, R.M. (1969). Corn Grain Processing Methods for High Concentrate Beef Cattle Diets. J. Anim. Sci. 29:153 (Abstr.)

6. Cardon, B.P. (1970). A Feeding Program for Milking Dairy Cows - NE-Milk. Feedstuffs, Nov. 14, 1970.

7. Crampton, E.W. and Lloyd, L.E. (1951). Studies with Sheep on the Use of Chromic Oxide as an Index of Digestibility of Ruminant Rations. J. Nutr. 45:319.

8. Cullison, A.E. (1961). Effect of Physical Form of the Ration on Steer Performance and Certain Rumen Phenomena. J. Anim. Sci. 20:478.

9. Davenport, E. (1897). On the Importance of the Physiological Requirements of the Animal Body; Results of an Attempt to Grow Cattle Without Coarse Feed. Illinois Agr. Exp. Sta. Bull. 46:362.

10. Ellenberger, H.B. and Schneider, B.H. (1927). Exercise as a Factor in Digestion Trials with Dairy Cows. Vermont Agr. Exp. Sta. Bull. 262.

11. Food and Agriculture Organization of the United Nations (1971). Agriculture Commodity Projections 1970-1980. F.A.O. Rome, Italy.

12. Garrett, W.N., Lofgreen, G.P. and Meyer, J.H. (1964). A Net Energy Comparison of Barley and Milo for Fattening Cattle. J. Anim. Sci. 23:470.

13. Gerken, H.J., Wise, M.B., Harvey, R.W., and Barrick, E.R. (1971). Whole Corn, Liquid Supplements and Polyethylene for Beef Cattle. J. Anim. Sci. 32:379. (Abstr.)

14. Geurin, H.B., Williamson, J.L., Thompson, J.C., Wilcke, H.L. and Bethke, R.M. (1959). Rolled Common Barley Serves as Both Grain and Roughage for Fattening Steers. J. Anim. Sci. 18:1489 (Abstr.)

15. Hale, W.H., Hubbert, F. Jr., Cadena, M. and Taylor, B. (1962). Milo-Barley Studies with Fattening Steers. J. Anim. Sci. 21:998. (Abstr.)

16. Hall, G.A.B., Absher, C.W., Totusek, R. and Tilman, A.D. (1968). Net Energy of Sorghum Grain and Corn for Fattening Cattle. J. Anim. Sci. 27:165.

17. Haskins, B.R., Wise, M.B., Craig, H.B., Blumer, T.N. and Barrick, E.R. (1969). Effects of Adding Low Levels of Roughages or Roughage Substitutes to High Energy Rations for Fattening Steers. J. Anim. Sci. 29:345.

18. Hironaka, R. and Slen, S.B. (1962). The Effects of Feed Consumption on Rate and Efficiency of Gain by Steers Fed on All Barley Ration. Can. J. Anim. Sci. 42:18.

19. Hixon, D.L., Hatfield, E.E. and Lamb, P.E. (1969). Comparison of Whole Shelled Corn with Cracked Corn in Cattle Finishing Diets. J. Anim. Sci. 29:161. (Abstr.)

20. Huffman, C.F. (1928). Hay is Necessary in Rations of Dairy Cattle; Unknown Factor Present in Hay Needed to Maintain Health of Dairy Cattle. Michigan Exp. Sta. Quart. Bull. 11: 1:3.

21. Klosterman, E.W., Ockaman, H.W. and Chahill, V.R. (1968). Net Energy of Ear Corn and Corn Silage for Steers and Heifers. J. Anim. Sci. 27:1166. (Abstr.)

22. Lofgreen, G.P., Bath, D.L. and Strong, H.T. (1963). Net Energy of Successive Increments of Feed Above Maintenance for Beef Cattle. J. Anim. Sci. 22:598.

23. McLaren, R.J., Matsushima, J.K., McCann, C.P., Brasher, T.E., Kellogg, G.E. and Lake, R.P. (1970). Extruded Corn for Beef Finishing Rations. J. Anim. Sci. 31:249. (Abstr.)

24. Morrison, F.B. (1956). Feeds and Feeding (22nd ed.) Morrison Pub. Co., Ithica, New York.

25. National Academy of Sciences - National Research Council (U.S.) (1970). Nutrient Requirements of Domestic Animals, No. 4. Nutrient Requirements of Beef Cattle. 4th revised ed., Washington, D.C.

26. National Research Council (1959). Joint United States-Canadian Tables of Feed Composition. Pub. 659. Washington, D.C.

27. Noblitt, C.G., Hardison, W.A., Huber, J.T. and Graf, G.C. (1963). Effect of Manual Total Collection of Feces Upon Nutrient Digestibilities. J. Dairy Sci. 46:67.

28. Pearson, A.M. (1966). Desirability of Beef - Its Characteristics and Their Measurements. J. Anim. Sci. 25:843-854.

29. Phar, P.A., Bradley, N.W., Little, C.O., Cundiff, L.V., Boling, J.A. (1971). Nutrient Digestibility Using Fecal Collection Apparatus and Indicator Method for Steers Fed ad libitum. J. Anim. Sci. 33: 695-697.

30. Richardson, D., Smith, E.F., Baker, F.H. and Cox, R.F. (1961). Effects of Roughage-Concentrate Ratio in Cattle Fattening Rations on Gains, Feed Efficiency, Digestion and Carcass. J. Anim. Sci. 20:316.

31. Schurch, A.F., Lloyd, L.E., Crampton, E.W. (1950). The Use of Chromic Oxide as an Index for Determining the Digestibility of a Diet. J. Nutr. 41:629-636.

32. Swan, H. and Lamming, G.E. (1969). Studies on the Nutrition of Ruminants. The Effect of Maize Based Diets Containing up to 70% Ground Barley Straw on the Liveweight Gain and Carcass Composition of Yearling Steers. Anim. Prod. 11:203.

33. Vance, Robert D., Preston, R.L., Cahill, V.R. and Klosterman, E.W. Net Energy Evaluation of Cattle-Finishing Rations Containing Varying Proportions of Corn Grain and Corn Silage. J. Anim. Sci. 34:851.

34. Waldo, D.R., Coppack, C.E., Smith, L.W., Moore, L.A. and Sykes, J.W. (1961). Annual Report of S-45 Regional Committee on the Nutrient Evaluation of Forage Crops. U.S. D.A., Washington, D.C.

35. White, T.W. and Reynolds, W.L. (1969). Various Sources and Levels of Roughage in Steer Rations. J. Anim. Sci. 28:705.