



Evaluation of pelleted or wafered rations for wintering or fattening beef cattle
by John J Matz

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Abstract:

Hereford steers were self-fed a fattening ration of pelleted concentrates, containing various combinations of feedstuffs, long grass hay and salt ad libitum in two similar experiments.

Whole pressed or decorticated safflower meal were compared to a combination of soybean and cottonseed meal as a protein source, fed on an equivalent protein basis. Barley preparation, steam rolled or ground barley, and the addition of oats and wheat millrun as partial replacements for barley were evaluated. The addition of safflower hulls as a partial replacement for beet pulp was also tested in pelleted concentrate rations for fattening steers.

There were no significant differences in gains, feed efficiency, feed consumption, carcass grades or yields, rib-eye area or marbling score and fat thickness in data collected. Evaluation of rumen data (Trial III) would indicate that, long grass hay was effective in reducing the incidence and severity of ruminal parakeratosis. Net returns were greatest on less complex rations where wheat millrun and oats were replaced with ground barley, and whole pressed or decorticated safflower meal were used as a protein source.

An 84-day wintering trial (Trial II) with Hereford steer calves tested gains, feed efficiency and net returns when calves were fed wafered or long alfalfa hay and two levels of concentrates. The treatments were as follows wafered + 0.91 kg. cone.; long + 0.91 kg. cone.; long + 1.82 kg. cone.; wafered + 1.82 kg. cone.

Average daily gains and kg. feed required per kg. gain for the calves were as follows; 0.73, 18.60; 0.59, 22.88; 0.72, 18.72; 0.80, 16.91, respectively. Average daily feed consumption was 6.18 kg. per calf.

The gains of calves fed wafered hay were greater ($P < 0.05$) than calves fed long hay. Gains of steers fed an average of 1.82 kg. concentrates daily gained significantly more ($P < 0.01$) than steers fed 0.91 kg. concentrates daily. Steers fed wafered hay and 1.82 kg. of concentrates daily gained faster ($P < 0.01$) than steers- fed long hay and 0.91 kg. concentrates daily; Feed efficiency was not significantly different. Estimated net returns" were highest for steers-fed wafered hay and increasing the level of concentrate feeding increased net returns slightly.

Subsequent gains of steers on the wintering ration in Trial II were tested statistically and- analysis of this data indicated steers wintered on long or wafered alfalfa hay and 0.91 kg. concentrates daily gained significantly faster ($P < 0.01$) in the following fattening period than steers wintered on an average of 1.82 kg. of concentrates daily.

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WINTERING OR FATTENING BEEF CATTLE

by

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ABSTRACT

Hereford steers were self-fed a fattening ration of pelleted concentrates, containing various combinations of feedstuffs, long grass hay and salt ad libitum in two similar experiments.

Whole pressed or decorticated safflower meal were compared to a combination of soybean and cottonseed meal as a protein source, fed on an equivalent protein basis. Barley preparation, steam rolled or ground barley, and the addition of oats and wheat millrun as partial replacements for barley were evaluated. The addition of safflower hulls as a partial replacement for beet pulp was also tested in pelleted concentrate rations for fattening steers.

There were no significant differences in gains, feed efficiency, feed consumption, carcass grades or yields, rib-eye area or marbling score and fat thickness in data collected. Evaluation of rumen data (Trial III) would indicate that long grass hay was effective in reducing the incidence and severity of ruminal parakeratosis. Net returns were greatest on less complex rations where wheat millrun and oats were replaced with ground barley, and whole pressed or decorticated safflower meal were used as a protein source.

An 84-day wintering trial (Trial II) with Hereford steer calves tested gains, feed efficiency and net returns when calves were fed wafered or long alfalfa hay and two levels of concentrates. The treatments were as follows: wafered + 0.91 kg. conc.; long + 0.91 kg. conc.; long + 1.82 kg. conc.; wafered + 1.82 kg. conc.

Average daily gains and kg. feed required per kg. gain for the calves were as follows: 0.73, 18.60; 0.59, 22.88; 0.72, 18.72; 0.80, 16.91, respectively. Average daily feed consumption was 6.18 kg. per calf.

The gains of calves fed wafered hay were greater ($P < 0.05$) than calves fed long hay. Gains of steers fed an average of 1.82 kg. concentrates daily gained significantly more ($P < 0.01$) than steers fed 0.91 kg. concentrates daily. Steers fed wafered hay and 1.82 kg. of concentrates daily gained faster ($P < 0.01$) than steers fed long hay and 0.91 kg. concentrates daily. Feed efficiency was not significantly different. Estimated net returns were highest for steers fed wafered hay and increasing the level of concentrate feeding increased net returns slightly.

Subsequent gains of steers on the wintering ration in Trial II were tested statistically and analysis of this data indicated steers wintered on long or wafered alfalfa hay and 0.91 kg. concentrates daily gained significantly faster ($P < 0.01$) in the following fattening period than steers wintered on an average of 1.82 kg. of concentrates daily.

INTRODUCTION

Fattening beef cattle in Montana is increasing in importance. In conjunction with this, producers of beef must be informed of ways in which to improve the efficiency and reduce the cost of production of meat animals. Pelletizing or wafering rations for beef cattle is one method utilized in the attempt to improve the efficiency and reduce the cost of production of meat animals.

Pellets or wafers are made in special machines, by great pressures, from roughages and concentrates, or from concentrates alone. These procedures generally require the ingredients to be ground before being compressed into a pellet or wafer. Pelletizing a ration involves an additional investment in rations for fattening beef cattle. It is desirable to formulate a ration in such a manner that this cost can be returned by increasing feed efficiency, gains, and net returns, and reducing waste and labor costs. In an attempt to study ration formulation and to determine the effects of feeding pelleted or wafered rations to fattening beef cattle, the three trials reported herein were conducted.

Trial I was initiated to study the effects of feeding concentrate pelleted rations with long hay ad libitum, in a fattening ration for yearling steers. The principal comparisons were steam rolled pelleted barley versus a combination of cottonseed meal and soybean meal as sources of protein, three levels of oats replacing barley, and the addition of safflower hulls to a pelleted concentrate ration.

Trial II was conducted to study the effects of feeding two levels of concentrates on the weight gains of steer calves when fed second cutting loose or wafered alfalfa hay in a wintering ration, and the effect of these

gains upon subsequent weight gains in a fattening period.

Trial III was initiated to compare decorticated or whole pressed safflower meal as substitutes for combinations of cottonseed meal and soybean meal as protein sources for fattening cattle. At the same time, two levels of oats, replacing ground barley, in concentrate pelleted rations with long hay fed ad libitum, are compared as energy sources in rations for fattening yearling steers.

The primary characteristics considered important to study in these trials with pelleted or wafered rations were as follows: daily gains, feed consumption, feed conversion, marbling score and carcass grade, rumen parakeratosis and net return. The data submitted in this manuscript are presented in the metric system. Appendix Table I presents factors necessary for use in converting data from the metric system to the English system. In addition, supplementary table in the English are presented in the appendix tables.

REVIEW OF LITERATURE

Concentrate:Roughage Ratio

Fattening rations for cattle generally are formulated to include a wide ratio of concentrates to roughages. Investigations with all-concentrate rations for beef cattle have been conducted by Wise et al. (1961) and Davis et al. (1963). Wise et al. (1961) observed that cattle are able to perform satisfactorily on all-concentrate rations containing 1.5 percent fiber for extended periods of time, provided the rations provide essential nutrients in adequate amounts. Davis et al. (1963) studied the effects of all-concentrate rations containing 2.7, 3.0, 6.0, and 7.6 percent crude fiber. These trials (Wise et al., 1961; Davis et al., 1963) are in agreement that cattle on higher fiber rations had significantly higher ruminal pH values. High fiber rations promote rumination, and rumination, in turn, promotes salivary secretions. The change in ruminal pH is felt to be due to the increased salivation (Bailey and Balch, 1961a, 1961b; Bailey, 1961a, 1961b).

Beeson et al. (1957) observed that when steers were self-fed the components of a ration, they selected more concentrates and less hay than was provided for steers hand-fed a mixed ration. The self-fed steers had 0.10 kg. greater average daily gain on substantially less feed per unit of gain.

McCroskey et al. (1961) studied the effects of rations containing 1:4 and 4:1 concentrate to roughage ratios on feedlot performance and carcass merit for beef cattle. Rate of gain and feed intake were significantly increased ($P < 0.01$) by pelleting the 1:4 ration. Pelleting the 4:1 rations resulted in no significant change in rate of gain, but caused a decrease in feed intake. Feed efficiency on both rations was improved slightly by

pelletting. Dressing percent was unaffected by pelletting the 1:4 ration, but slightly reduced by pelletting the 4:1 ration. This is in general agreement with earlier work (Whiting, 1957) studying concentrate roughage ratios of 1:2, 1:1, and 2:1.

Lamb fattening rations per se are generally lower in energy value than steer fattening rations. Bell et al. (1955) and Church et al. (1959, 1961) reported the most desirable levels appeared to be 70 percent roughage and 30 percent concentrates. Bell et al. (1955), using dehydrated alfalfa, observed that a pelleted ration of 65 percent alfalfa and 30 percent corn produced daily gains of 0.16 kg., while pellets of 55 percent alfalfa and 45 percent corn produced gains of 0.10 kg. However, with unpelleted rations, using chopped alfalfa hay and cracked corn, 55 percent alfalfa and 45 percent corn proved superior to 65 percent alfalfa and 35 percent corn as measured by gains of lambs.

Pelleting of low roughage rations (Hartman et al., 1959; Woods and Rhodes, 1962) improved gains of lambs over conventional rations; however, improvements were not as great as those attained by merely grinding and mixing low roughage rations. Pelletting of high roughage rations, however, (Hartman et al., 1959; Woods and Rhodes, 1962; Donefer et al., 1963) resulted in increased feed consumption, increased gains, and decreased feed required per unit of gain.

Safflower Meal as a Protein Source

Safflower is an oilseed crop which has been grown commercially on a small scale in North Africa, the Middle East, and Southern Europe for many decades. In the past three decades, some interest has been noted in

commercial seeding of this plant (Baker et al., 1960a) in the United States, with the principal areas being California, Montana and Nebraska. The value of safflower meal as a possible livestock feed in digestion trials has been tested with wether lambs. The results of this trial (Goss and Otagaki, 1954) are presented in Table I. The digestion coefficient of 88 percent for crude protein of decorticated safflower meal is comparable to values reported by Morrison (1959) for soybean meal (92 percent) and cottonseed meal (82 percent).

TABLE I. SAFFLOWER MEAL DIGESTION TESTS. 1/

Chem. Comp.	Moisture	C. Prot.	E.E.	C.F.	Ash	N.F.E.	T.D.N.
Decorticated Meal	8.0	36.0	7.6	17.5	7.4	23.5	
Dig. Coef.		C. Prot.	E.E.	C.F.		N.F.E.	T.D.N.
Decorticated Meal		88.0	89.0	23.0		63.0	66.0

1/ Adapted from Goss and Otagaki, 1954.

Machines have become available to remove most of the hull from the seeds of the safflower plant, and such machines are in operation in most areas where safflower is grown. A process such as this adds to the cost of the decorticated meal. The percentage of the hull of safflower seed varies from 40 to 50 percent, and the fiber content of the meals varies with the degree of decortication of the seed (Baker et al., 1960a).

Safflower meal, as a protein supplement for chickens, has been evaluated by Kratzer et al. (1947) (1951), Grau et al. (1953), and Peterson et al. (1957). Decorticated safflower meal has proven to be slightly deficient

in arginine, methionine, lysine, glycine, and cystine for chicks. The deficiency has not proven to be too serious, and safflower can replace soybean oil meal in rations for chickens, provided the ration contains 5 percent fishmeal and 5 percent meatmeal.

Protein quality, however, is of less concern in ruminant nutrition than in monogastric nutrition. Safflower meal has been found to be a good protein source for sheep and cattle. Baker et al. (1960b) and Thomas et al. (1962) reported that safflower is capable of replacing soybean meal or other protein supplements when fed to furnish the same amount of protein in wintering rations of beef cattle. Safflower meal fed at a protein level equivalent to that furnished by commonly used oil meals has been tested in rations (Baker et al., 1951; Hilston et al., 1951, 1952; Faulkner et al., 1952) for fattening lambs and beef cattle. When fed on this basis, gains for fattening lambs and cattle are not significantly different from gains of cattle fed more commonly used oil meals. No significant differences in carcass grades of animals fed safflower meal can be detected when compared to other oil meal supplements.

Factors Associated with Pellet Feeding

Rumination and Salivary Secretion

Gordon (1958a) studied the effects of grass hay fed whole, chopped (5.08 cm. lengths) and ground into fine meal, upon total time spent ruminating. Time spent ruminating was slightly longer for steers consuming chopped hay (5.08 cm. lengths) as compared to the long hay. Significantly, greater time ($P < 0.01$) was spent in ruminating the long and chopped hay than the hay ground into a fine meal. The material stimulating rumination in this

trial did not appear to be freshly ingested fodder, but that which had been macerated in the rumen for some time. After the initial chewing accompanying ingestion, the 5.08 cm. chopped grass hay may come to this consistency more rapidly than long grass, and thus, increase the total time spent in rumination. The ground fodder appeared to be of too fine a consistency to stimulate rumination.

The average time spent ruminating (Gordon, 1958a, 1958b) is reported to be 8 to 9 hours daily when cattle consumed conventional roughage rations. Rumination became markedly irregular (Gordon, 1958b) when concentrates were fed and averaged approximately 2.5 hours daily. There was also a high degree of pseudorumination when sheep were fed concentrates.

The rates of salivary secretions in cattle on various types of rations were studied by Bailey and Balch (1961a, 1961b). Rates of salivary secretions varied with the following magnitude: Grass > Hay > Hay + Dairy Cubes > Hay + Concentrate > Silage. The act of eating per se contributed to the establishment of a pattern of secretion, which was greater during rest after small meals than during rest after large meals. Bailey and Balch (1961a) have shown that the average rate of secretion of saliva in cattle is low during and immediately following a meal. Secretions increased markedly during rumination, especially when mastication was occurring. The secretion rate decreased rapidly following rumination and increased rapidly again just before rumination began. Decreases in the rumen pH or additions of acetic acid apparently do not function in controlling salivary secretions (Bailey and Balch, 1961b).

Ruminal Parakeratosis

One of the earliest reports of ruminal parakeratosis is reported by Jensen et al. (1954) who defined the condition as "A noncontagious disease, characterized grossly by hardening and enlargement of the papillae, and microscopically by accumulation of excessive layers of keratinized, nucleated, squamous, epithelial cells on the papillae". Only the papillae are affected, and this may vary individually from a few to all papillae being affected. Jensen et al. (1954, 1958) studied the effects of roughage-concentrate ratios on the incidence of this condition in both sheep and cattle. In both cases, concentrate-roughage ratios of 3:1 resulted in a higher incidence of ruminal parakeratosis than did 1:1 ratios. Pelleting the rations increased again the occurrence of ruminal parakeratosis. The high occurrence of ruminal parakeratosis when cattle are fed pelleted rations is also reported by Beardsley et al. (1959), Jordan (1959), Pounden et al. (1960), Vidacs and Ward (1960), and Gilliland et al. (1962). Garrett et al. (1961) reported that finely ground and pelleted feeds, when compared to regularly milled and pelleted feeds, increased the incidence and severity of rumen parakeratosis in cattle.

Jordan (1959) and Garrett et al. (1961) reported that long hay or straw fed in limited amounts were effective in reducing the severity of parakeratosis, but was not effective in completely eliminating it. Cattle on complete pelleted rations have a craving for additional long roughage. This can be satisfied by providing small amounts of poor quality roughage such as straw. Increased gains and feed consumption were noted (Jordan, 1959; Garrett et al., 1961) when long roughage was fed with pelleted concentrate

rations.

In the reports of Jensen et al. (1954, 1958), it was shown that cattle going on a full-fed concentrate ration in 12 days developed a significantly greater incidence of parakeratosis than did cattle going on a full-fed concentrate ration in 30 days. Parakeratosis became apparent as soon as 35 days after the initiation of concentrate feeding. In feeding trials with sheep (Jensen et al., 1958), no differences in daily gain could be attributed to the incidence or severity of ruminal parakeratosis. It is felt that ruminal parakeratosis (Vidacs and Ward, 1960; Garrett et al., 1961) may inhibit absorption of the volatile fatty acids, thus reducing gains of animals. However, no correlation between rate of absorption of volatile fatty acids and the severity of ruminal parakeratosis has yet been reported.

Jensen et al. (1954) reported that ruminal parakeratosis may also be a predisposing factor in the development of secondary infections in other areas of the body. Spherophorus necrophorus, associated with liver abscesses, may be able to penetrate areas of the rumen wall affected by parakeratosis. Upon penetration, the organism may enter the portal blood stream and be carried to the liver where secondary infections may develop. Pounden et al. (1960) reported parakeratosis may also be associated with feedlot bloat. Inflammation in the anterior portions of the esophagus and related tissues may cause retention of gases formed in fermentations. It is concluded that sphincter mechanisms exist in the anterior portion of the esophagus which are seriously disturbed by the inflammation of parakeratosis.

Coarseness of Grind and Pellet Size

At present, pelleting is the most drastic physical change to which

feed stuffs are subjected in commercial practice. In the pelleting process, heat and pressure are applied to a ground material. Pellets are made from forages or concentrates, or a combination of the two, and usually consist of finely ground forage compressed into a pellet 6.35 mm. to 19.05 mm. in diameter and 6.35 mm. to 38.10 mm. in length. The bulk density of pellets is about 0.65 kg. per cubic decimeter (Dobie, 1959).

Usually wafers consist of an agglomerated feed formed by compacting fibrous ingredients which have a mean particle length of 2.54 cm. or greater, and a bulk density of 0.32 to 0.49 kg. per cubic decimeter (Vander Noot and O'Conner, 1962). The wafers may be round, 5.08 to 7.62 cm. in diameter, or square, and usually 2.54 to 15.34 cm. in length. The wafering process for forages is becoming increasingly popular to people interested in feeding forages in forms other than in pelleted or loose forms. Wafering has become increasingly popular where hay must be hauled long distances (Pratt, 1962).

Ray and Drake (1959) studied the effects of grain preparation on preferences shown by beef cattle for corn, milo, and oats. The preparations tested were whole, coarsely ground, finely ground, pellets and ground pellets. Calves offered more than one grain preparation were selective in their choice. First choice preferences indicated significant differences between preparations but not between grains. Highly significant differences were observed in consumption due to preparation. Finely ground grains were consumed in smaller quantities ($P < 0.01$) than whole or coarsely ground preparations. Pellets were more preferable ($P < 0.01$) than ground pellets. The ground pellets and finely ground grains were seldom given first choice rating by the calves and were generally consumed in smaller amounts. Church

et al. (1959) and Perry et al. (1960) reported no significant differences in responses of lambs fed pellets of different sizes and containing feed stuffs of different particle sizes.

Data on the effect of forage preparation for different forages fed to calves or yearlings are shown in Table II. Calculated on an individual basis and averaged, grinding a long hay increased daily feed intake by 16 percent, daily gain by 30 percent, and decreased feed required per unit of gain by 15 percent. Wafering long hays increased feed consumption 22 percent, daily gain 23 percent, and the amount of feed required per unit of gain by 23 percent.

It is generally accepted that less response is obtained from grinding, pelleting or wafering a high quality forage than one of poor quality. This appears logical since one would expect animals to eat more of a highly palatable forage than an unpalatable one, but there are few published reports to verify this assumption. Thomas and Molitorisz (1962) fed alfalfa hay of high, medium and low quality in baled or wafered forms to dairy animals. The greatest response from the wafering process resulted from wafering the high quality hay, while dairy heifers consuming a poor quality baled hay made greater gains and consumed more feed than heifers consuming a poor quality wafered hay. Keyes (1964), however, in comparing baled and wafered alfalfa hay of poor quality fed to Holstein steers (Table II, 1962 trial), showed an increased consumption of poor quality wafered hay (1.22 kg.), but decreased daily gains and increased feed required per unit of gain, when compared with baled hay. Cullison (1961) fed coastal bermuda grass and obtained improvements in intake, gain and feed conversion from

TABLE II. EFFECT OF ROUGHAGE PREPARATION ON CATTLE PERFORMANCE

Forage:	Daily Intake (kg.)				Avg. Daily Gain (kg.)				Kg. Feed/kg. Gain			
	Long	Meal	Wafer	Pellet	Long	Meal	Wafer	Pellet	Long	Meal	Wafer	Pellet
Coastal Bermuda Grass (Cullison, 1961)	5.64	7.05		7.45	0.33	0.50		0.66	37.40	28.60		24.86
Meadow Hay (Wallace <i>et al.</i> , 1961)		4.50	4.59	5.59		0.17	0.14	0.32		58.96	74.14	38.06
Alfalfa Hay (Weir <i>et al.</i> , 1959)	8.00			9.32	0.82			0.99	21.56			20.79
Alfalfa Hay (Weir <i>et al.</i> , 1959)		8.77		10.18		0.80		1.01		24.27		22.22
Chopped Alfalfa Hay (McGroskey <i>et al.</i> , 1961)		8.95		10.23		0.84		1.04		23.54		21.78
Chopped Alfalfa Hay (McGroskey <i>et al.</i> , 1961)		12.14		14.36		0.85		1.04		31.24		30.58
Alfalfa Hay (Garrett <i>et al.</i> , 1961)		8.73	8.14	9.05		0.91	0.85	0.95		22.88	22.88	23.10
Coastal Bermuda Grass (Beaty <i>et al.</i> , 1960)	5.18			6.45	0.48			0.95	26.51			16.37
Alfalfa Hay, 1962 (Keyes, 1964)	11.09		12.31		0.75		0.66		32.34		40.92	
Alfalfa Hay, 1963 (Keyes, 1964)	8.55		10.00		0.64		0.95		28.07		23.10	
Prairie Hay (Nelson & Furr, 1960)	4.82			5.82	0.13			0.21	76.34			59.40
Total	43.28	50.14	35.04	78.45	3.15	4.07	2.60	7.17	222.22	189.49	161.04	257.16
Average	7.21	8.36	8.76	8.72	0.53	0.69	0.65	0.80	37.04	31.58	40.26	28.57
% Change		15.95	21.50	20.94		30.19	22.64	50.94		-14.74	8.69	-22.87

pelleting long hay of 1.81 kg., 0.33 kg., and 12.54 kg. per kg. gain respectively. Nelson and Furr (1960), feeding prairie hay, obtained similar responses in intake, gain and feed conversion of 1.00 kg., 0.08 kg., and 16.94 kg. of hay per kg. gain respectively. Wallace et al. (1961) studied the effects of feeding a low quality meadow hay in meal, wafered or pelleted forms. Wafering and pelleting this meadow hay, it is noted (Table II), increased daily feed consumption and significantly lowered the amount of feed required per unit of gain. Pelleting of this hay significantly increased the daily gain, while wafering slightly decreased average daily gains. It is obvious a poorly accepted forage can be made more acceptable by wafering or pelleting.

The effects of chopping and pelleting roughages for lambs are presented in Table III. Pelleting the chopped alfalfa hay increased the daily gain, daily feed intake, and decreased the amount of feed required per unit of gain by 27 percent, 50 percent and 13 percent respectively. The work of Nicholson and Cunningham (1964) substantiates earlier evidence of increased consumption and gains made when poor quality forages are pelleted, as compared to long forages. Nicholson and Cunningham (1964), reported that pelleting poor quality roughage doubles daily feed intake and increased daily gain by five times, on an average.

Table IV represents the data of the effects of ration preparation on performance of beef cattle. Based on a high, medium or low level of concentrates, the data is calculated on an individual basis and averaged for comparison. When compared to conventional rations, a high concentrate ration fed as a meal slightly decreased daily consumption (0.2 percent) and

TABLE III. EFFECT OF ROUGHAGE PREPARATION ON LAMB PERFORMANCE.

Ration:	Daily Intake (kg.)			Avg. Daily Gain (kg.)			Kg. Feed/kg. Gain	
	Coarse			Coarse			Coarse	Pellet
	Long	Grind	Pellet	Long	Grind	Pellet	Grind	Pellet
Alfalfa Hay (Meyer <u>et al.</u> , 1959a)		1.27	1.63		0.11	0.17	25.58	20.75
Alfalfa Hay (Meyer <u>et al.</u> , 1959b)		1.13	1.48		0.12	0.18	19.99	17.87
Dehydrated Alfalfa (Weir <u>et al.</u> , 1959)		1.41	1.68		0.14	0.18	22.68	20.75
Total		3.81	4.79		0.37	0.53	68.25	59.37
Average		1.27	1.60		0.12	0.18	22.75	19.79
% Change			26.77			50.00		-13.01

TABLE IV. EFFECT OF RATION PREPARATION ON BEEF CATTLE PERFORMANCE

Ration:	Daily Intake (kg.)				Avg. Daily Gain (kg.)				Kg. Feed/kg. Gain			
	Long	Meal	Wafer	Pellet	Long	Meal	Wafer	Pellet	Long	Meal	Wafer	Pellet
<u>70-80 percent Conc. (High)</u>												
McCroskey <i>et al.</i> (1961)		11.50		10.45		1.09		1.11		23.32		20.68
McCroskey <i>et al.</i> (1961)		8.50		7.36		1.00		0.86		18.70		18.48
Ralston <i>et al.</i> (1963)						1.44		1.25		15.33		16.08
Jordan (1959)	9.05			8.45	1.15			1.10	17.31			16.92
Cullison (1961)	8.95	8.95		7.64	1.10	1.15		0.99	18.00	17.07		17.05
Cullison (1961)	7.78	7.02		6.15	0.95	0.92		0.75	17.95	16.76		18.17
Beardsley <i>et al.</i> (1959)	12.63	11.95		10.05	1.22	1.35		1.18	22.88	19.58		18.70
Total	38.41	47.92		50.10	4.42	6.95		7.24	76.14	110.76		126.08
Average	9.60	9.58		8.35	1.11	1.16		1.03	19.04	18.46		18.01
% Change		- .20		-13.02		4.50		-7.21		-3.05		-5.41
<u>45-60 percent Conc. (Med.)</u>												
Garrett <i>et al.</i> (1961)		9.95	10.86	9.50		1.20	1.28	1.21		26.40	25.96	28.16
Weir <i>et al.</i> (1959)		9.09		7.41		1.12		0.97		17.80		16.90
Beardsley <i>et al.</i> (1959)		12.41		11.05		1.23		1.22		22.22		20.02
Whiting (1957)				7.36				0.84				19.40
Garrett <i>et al.</i> (1961)		7.09	8.91	9.05		0.92	1.21	1.14		28.60	29.92	27.94
Total		38.54	19.77	44.37		4.47	2.49	5.38		95.02	55.88	112.42
Average		9.64	9.89	8.87		1.12	1.25	1.08		23.76	27.94	22.48
% Change			2.59	-7.99			11.61	-3.57			17.59	-5.39

TABLE IV. (Continued)

Ration:	Daily Intake (kg.)			Avg. Daily Gain (kg.)			Kg. Feed/kg. Gain		
	Long	Meal	Wafer Pellet	Long	Meal	Wafer Pellet	Long	Meal	Wafer Pellet
<u>20-40 percent Conc. (Low)</u>									
McCroskey <u>et al.</u> (1961)	12.14		14.36	0.85		1.04	31.24		30.58
McCroskey <u>et al.</u> (1961)	8.95		10.23	0.84		1.04	23.54		21.78
Whiting (1957)			6.95			0.73			21.03
Beardsley <u>et al.</u> (1959)			11.86	1.12		1.27	23.32		20.46
Weir <u>et al.</u> (1959)	9.09		9.36	0.94		1.04	21.27		20.20
Total	30.18		52.76	3.75		5.12	99.37		114.05
Average	10.06		10.55	0.94		1.02	24.84		22.81
% Change			4.87			8.51			-8.17

the amount of feed required per unit of gain (0.3 percent), but increased by 4.5 percent the daily gains of animals fed the meal ration. Pelletizing of the high concentrate rations decreased daily intake 13 percent, daily gains 7 percent, and decreased the amount of feed required per unit of gain (5 percent). This data substantiates the opinion of authors consulted where the response of beef cattle to grinding or pelletizing of high concentrate rations has been small. Of particular significance is the reduction in daily feed intake of 13 percent and daily gains of 7 percent.

Pelletizing a medium concentrate ration, when compared to the ration fed in a meal form, decreased daily feed intake and average daily gains by 8 percent and 4 percent respectively, and decreased the amount of feed required per unit of gain by 5 percent. Wafering a medium concentrate fattening ration (Garrett et al., 1961), while representing only two trials, indicated increased feed consumption and daily gain of 3 percent and 12 percent respectively. Using a 7.62 cm. x 7.62 cm. wafer in these trials required slightly more feed per unit of gain, as compared to the same rations fed as a meal.

Pelletizing a low concentrate ration improved daily feed consumption, gains, and increased the amount of feed per unit of gain by 5, 8, and 8 percent respectively. The important comparisons in Table IV are the comparisons of high, medium, and low concentrate rations for cattle. In all data consulted, it is apparent that pelletizing of high roughage rations improved performance of beef cattle more than low roughage rations.

Pelletizing rations for fattening lambs has been summarized in Table V, with calculations based on individual data and averaged. Grinding or

TABLE V. EFFECT OF RATION PREPARATION ON LAMB PERFORMANCE

Ration:	Daily Intake (kg.)				Avg. Daily Gain (kg.)				Kg. Feed/kg. Gain			
	Coarse		Fine		Coarse		Fine		Coarse		Fine	
	Long	Grind	Meal	Pellet	Long	Grind	Meal	Pellet	Long	Grind	Meal	Pellet
<u>60-70 percent Conc.</u>												
Hartman <u>et al.</u> (1959)		1.99		2.00		0.26		0.25		14.74		14.74
Hartman <u>et al.</u> (1959)		2.09		1.86		0.24		0.23		18.79		17.91
Thomas <u>et al.</u> (1959)		1.53		1.70		0.18		0.23		18.85		16.26
Thomas <u>et al.</u> (1954)		1.66		1.62		0.16		0.19		22.18		19.29
Perry <u>et al.</u> (1959)				1.41				0.15				21.12
Woods & Rhodes (1962b)			1.40	1.30			0.20	0.19			15.80	15.07
Gate <u>et al.</u> (1955)			1.35	1.31			0.18	0.20			16.08	14.70
Gate <u>et al.</u> (1955)			1.57	1.71			0.17	0.23			19.69	16.59
Gate <u>et al.</u> (1955)			1.40	1.59			0.13	0.20			23.08	17.18
Thomas <u>et al.</u> (1960)		1.93		1.99		0.20		0.22		21.65		20.09
Total		5.12	9.80	16.49		0.54	1.18	2.09		68.68	108.18	172.95
Average		1.71	1.63	1.65		0.18	0.20	0.21		20.89	18.03	17.30
% Change			-4.68	-3.51			11.11	16.67			-13.69	-17.19

TABLE V. (Continued)

Ration:	Daily Intake (kg.)				Avg. Daily Gain (kg.)				Kg. Feed/kg. Gain			
	Coarse		Fine		Coarse		Fine		Coarse		Fine	
	Long	Grind	Meal	Pellet	Long	Grind	Meal	Pellet	Long	Grind	Meal	Pellet
<u>40-59 percent Conc.</u>												
Botkin & Paules (1955)			1.61	1.75				0.15 0.19			23.41	20.53
Botkin & Paules (1955)			1.60	1.98				0.15 0.21			23.28	20.11
Botkin & Paules (1955)			1.60	1.97				0.16 0.21			22.33	20.09
Botkin & Paules (1955)			1.55	1.93				0.15 0.21			22.42	20.02
Nicholson & Cunningham (1964)		1.15		1.69		0.08		0.20				
Hanke & Jordan (1963)	1.27			1.22	0.14			0.12	20.28			23.19
Hanke & Jordan (1963)	1.31			1.22	0.15			0.11	19.38			23.43
Hanke & Jordan (1963)	1.30			1.18	0.16			0.11	17.34			23.17
Esplin et al. (1957)			1.50	1.77				0.20 0.23			16.72	16.50
Esplin et al. (1957)			1.32	1.32				0.11 0.17			19.14	18.26
Thomas et al. (1960)		2.00		2.06	0.20			0.20	21.71			20.50
Thomas et al. (1959)		1.71		1.88	0.20			0.21	19.40			19.47
Hartman et al. (1959)			1.96	2.22				0.24 0.27			17.75	18.11
Hartman et al. (1959)			1.95	2.23				0.19 0.22			22.02	22.53
Total	3.88	4.86	13.09	24.42	0.45	0.48	1.35	2.66	57.00	41.11	167.07	265.91
Average	1.29	1.62	1.64	1.74	0.15	0.16	0.17	0.19	19.00	20.56	20.88	20.45
% Change			1.22	7.41			6.25	18.75			1.56	-2.06

Table V. (Continued)

Ration:	<u>Daily Intake (kg.)</u>				<u>Avg. Daily Gain (kg.)</u>				<u>Kg. Feed/kg. Gain</u>			
	<u>Coarse</u>		<u>Fine</u>		<u>Coarse</u>		<u>Fine</u>		<u>Coarse</u>		<u>Fine</u>	
	Long	Grind	Meal	Pellet	Long	Grind	Meal	Pellet	Long	Grind	Meal	Pellet
<u>30-39 percent Conc.</u>												
Perry <u>et al.</u> (1959)				1.82				0.20				19.91
Woods & Rhodes (1962b)	1.47			1.57	0.16			0.20	20.02			17.12
Thomas <u>et al.</u> (1960)	2.11			2.00	0.20			0.21	21.71			20.50
Weir <u>et al.</u> (1959)	1.27			1.45	0.14			0.16	20.15			19.73
Thomas <u>et al.</u> (1959)	1.80			2.09	0.15			0.23	25.34			19.87
Total	6.65			8.93	0.65			1.00	87.22			97.13
Average	1.66			1.79	0.16			0.20	21.81			19.41
% Change				7.83				25.00				-11.00

pelleting a high concentrate ration for sheep, when compared to a ration coarsely ground, resulted in a decreased daily intake of feed of 5 percent as compared to a ration fed as meal, and 4 percent when fed as a pellet.

In contrast to the performance of beef cattle, daily gains of lambs were increased by 11 percent and 17 percent respectively as a result of fine grinding and pelleting high concentrate rations. No valid explanation can be given as to why gains of lambs increased as a result of fine grinding and pelleting, while gains of cattle decreased (Table IV). The decrease in the amount of feed required per unit of gain is in agreement with the literature. When compared with a coarsely ground ration, fine grinding a high concentrate ration resulted in a 14 percent decrease in the amount of feed required per unit of gain, and pelleting a 17 percent decrease. This is in agreement with results of high concentrate rations fed to beef cattle in Table IV.

In Table V, comparisons are made only between coarse, fine grinding and pelleting in rations, when containing 50 to 60 percent concentrates. Feeding finely ground or pelleted rations increased daily consumption 1 percent and 7 percent respectively, and daily gains by 6 percent and 19 percent, respectively. Feed per unit of gain is increased slightly (1 percent) as a result of pelletting.

Few trials were encountered comparing long hay and whole grains, and it is of interest to note the trials of Hanke and Jordan (1963) presented in Table V. Long alfalfa-brome hay and whole barley of three-bushel weights were compared with the same completely pelleted rations. Feed consumption and daily gains were depressed as a result of pelletting and feed required

per unit of gain was increased. In the whole rations, feed consumption and daily gains decreased as the bushel weights of the barley decreased, while feed per unit of gain increased. In the pelleted rations, there were no significant changes in feed consumption, daily gains nor feed conversion as a result of feeding barley of 23.64, 20.00 or 16.14 kg. per bushel.

Pelleting of coarse ground rations containing 30 to 40 percent concentrates for lambs resulted in increased consumption (8 percent) and daily gains (25 percent) and decreased the amount of feed required per unit of gain. This is in agreement with the literature and results of Table IV, showing that responses were greater as a result of pelleting high roughage rations.

Table VI presents individual data on carcass yields of sheep and cattle. Based on the averages of the compiled individual data for beef cattle, it would appear that wafering or pelleting rations containing 20 to 80 percent concentrates has little effect upon the carcass yields in beef cattle. In contrast, lamb carcass yields are increased slightly as a result of grinding and pelleting an all roughage ration (Table VI). Pelleting an all forage ration increased carcass yields by 6 percent when compared with a coarsely ground ration. Pelleting a low concentrate ration (30 to 40 percent) resulted in a very slight increase (0.46 percent) in carcass yields compared to rations in a coarsely ground state. Pelleting or fine grinding a medium (40 to 50 percent) concentrate ration increased yields by 4 percent and 3 percent, and pelleting or fine grinding a high concentrate (60 to 70 percent) increased carcass yields by 4 percent and 8 percent respectively. It would appear that as the concentrate in a ration increased, the response,

TABLE VI. EFFECTS OF RATION PREPARATION ON CARCASS YIELDS (PERCENT)

Beef Carcass Yields (%)	Long	Coarse Grind	Meal	Fine Meal	Wafer	Pellet
<u>70-80 percent Conc. (High)</u>						
McCroskey <u>et al.</u> (1961)			61.7			60.3
McCroskey <u>et al.</u> (1961)			61.8			63.1
Jordan (1959)	60.06					58.41
Cullison (1961)	59.74		60.76			59.63
Cullison (1961)	59.48		59.29			56.99
Total	179.28		243.55			298.43
Average	59.76		60.89			59.69
% Change			1.89			-0.12
<u>50-60 percent Conc. (Med.)</u>						
Garrett <u>et al.</u> (1961)			62.7		62.1	61.6
Weir <u>et al.</u> (1959)			59.5			60.5
Garrett <u>et al.</u> (1961)			60.1		60.2	60.4
Total			182.30		122.3	182.5
Average			60.77		61.15	60.83
% Change					0.63	0.10
<u>20-40 percent Conc. (Low)</u>						
McCroskey <u>et al.</u> (1961)			59.4			58.8
McCroskey <u>et al.</u> (1961)			59.4			59.9
Weir <u>et al.</u> (1959)			59.5			59.6
Total			178.3			178.3
Average			59.4			59.4
% Change			0.0			0.0

TABLE VI. (Continued)

Lamb Carcass Yields (%)	Long	Coarse Grind	Meal	Fine Meal	Wafer	Pellet
<u>100 percent hay</u>						
Meyer <u>et al.</u> (1959a)		45.8				48.8
Weir <u>et al.</u> (1959)		49.8				53.1
Total		95.6				101.9
Average		47.8				51.0
% Change						6.43
<u>60-70 percent Conc. (High)</u>						
Thomas <u>et al.</u> (1960)		47.3				49.3
Cate <u>et al.</u> (1955)				48.98		50.63
Cate <u>et al.</u> (1955)				49.94		51.97
Cate <u>et al.</u> (1955)				52.3		51.64
Perry <u>et al.</u> (1959)						48.0
Thomas <u>et al.</u> (1954)		46.9				47.0
Thomas <u>et al.</u> (1954)		48.7				49.1
Hartman <u>et al.</u> (1959)				55.22		48.82
Hartman <u>et al.</u> (1959)				49.80		48.36
Total		142.9		254.24		444.82
Average		47.63		51.25		49.42
% Change				7.60		3.76
<u>40-50 percent Conc. (Med.)</u>						
Hartman <u>et al.</u> (1959)				47.92		48.91
Hartman <u>et al.</u> (1959)				46.54		49.23
Thomas <u>et al.</u> (1959)		47.7				48.3
Thomas <u>et al.</u> (1960)		48.4				48.2
Esplin <u>et al.</u> (1957)				52.1		52.8
Esplin <u>et al.</u> (1957)				51.4		51.6
Total		96.1		197.96		299.04
Average		48.05		49.49		49.84
% Change				3.00		3.73

TABLE VI. (Continued)

Lamb Carcass Yields (%)	Long	Coarse Grind	Meal	Fine Meal	Wafer	Pellet
<u>30-40 percent Conc. (Low)</u>						
Thomas <u>et al.</u> (1959)		49.5				48.4
Weir <u>et al.</u> (1959)		52.4				55.2
Thomas <u>et al.</u> (1960)		49.5				49.0
Perry <u>et al.</u> (1959)						50.2
Total		151.4				202.8
Average		50.47				50.70
% Change						0.46

as measured by carcass yields, increased. Disregarding concentrate levels, and considering the all data (30 to 80 percent concentrates), there appears to be little advantage, as measured by carcass yields, in grinding or pelleting rations when compared to a coarsely ground ration. Considered in this manner, a slight increase in carcass yield in favor of fine grinding and pelleting is noted.

Table VII presents individual data of the effects of pelleted and unpelleted rations upon carcass grades of sheep. Considering the data of Meyer et al. (1959a) and Weir (1959), it is quite apparent that pelleting increased the carcass grades when all-roughage rations were fed. This is undoubtedly due to the greater response, as measured by daily gains, intake, and feed conversion, due to pelleting high roughage rations reported in Table III. Disregarding energy levels of rations, Table VII would indicate, on a percentage basis, that pelleted rations have increased carcass grades in sheep.

With beef cattle, Richardson et al. (1961) reported that carcass grade improved significantly ($P < 0.05$) as the level of concentrate in the ration increased (1:1, 1:3 and 1:5). Weir et al. (1959) studied the effects of pelleting high roughage rations (Table VIII) and noted significant increases in carcass grades with pelleted rations. This would be in agreement with the results of the lamb data shown in Table VII.

McCroskey et al. (1961) studied the effects of pelleting 1:4 and 4:1 concentrate to roughage rations in beef rations. Pelleting the 1:4 rations significantly increased carcass grades, while pelleting the high concentrate rations (4:1) decreased carcass grades. Slight declines in carcass grades

TABLE VII. EFFECTS OF RATION PREPARATION ON CARCASS GRADES OF SHEEP

Sheep: Ration Carcass Grades	Unpelleted				Pelleted			
	Choice	Good	Utility	Cull	Choice	Good	Utility	Cull
<u>All Roughage</u>	<u>Number of carcasses</u>				<u>Number of carcasses</u>			
Meyer <u>et al.</u> (1959a)		2	2	2	4	2		
Weir <u>et al.</u> (1959)	1	3	2			5	1	
Weir <u>et al.</u> (1959)	3	7			9		1	
<u>30-70 percent Conc.</u>								
Thomas <u>et al.</u> (1950)	15	8			9	13		
Thomas <u>et al.</u> (1960)	14	4			17			
Cate <u>et al.</u> (1955)	32	19		1	48	3		
Cate <u>et al.</u> (1955)	25	20	5		37	13	2	
Cate <u>et al.</u> (1955)	44	5			42	6		
Weir <u>et al.</u> (1959)	18				17			
Thomas <u>et al.</u> (1959)	15	2	2		10	12		1
Thomas <u>et al.</u> (1959)	17	6			11	10	2	2
Weir <u>et al.</u> (1959)	8	2			10			
Thomas <u>et al.</u> (1960)	18				16	2		
Total	210	78	11	3 (302)	230	66	6	3 (305)
Average %	69.54	25.83	3.64	0.99	75.41	21.64	1.97	0.98

are also noted by Ralston et al. (1963) and Cullison (1961) when high concentrate rations were fed. Jordan (1959) and Weir (1959) reported declines in carcass grades by pelleting high concentrate feeding (Table VIII). This response is undoubtedly due to the marked decreases in food consumption and daily gains noted in Table IV, when pelleted high concentrate rations are fed to beef cattle.

TABLE VIII. EFFECTS OF RATION PREPARATION ON CARCASS GRADES OF CATTLE.

Ration: Carcass grades:	Unpelleted			Pelleted		
	Prime	Choice	Good	Prime	Choice	Good
<u>30-70 percent Conc.</u>	<u>(No. Carcasses)</u>			<u>(No. Carcasses)</u>		
Jordan (1959)		3	5		1	7
Weir <u>et al.</u> (1959)		9			7	2
Weir <u>et al.</u> (1959)		8	1	1	8	
<u>Alfalfa-100%</u>						
Weir <u>et al.</u> (1959)		3	6		9	

The response, as measured by increased carcass grade (Weir et al., 1959, Table VIII) is in agreement with the response of carcass grade noted for lambs for all roughage rations.

Digestibility

The effects of feed preparation upon the apparent digestion coefficients for alfalfa hay are presented on an individual basis, averaged and compared in Table IX. Examination of Table IX indicates increased digestion coefficients for dry matter, protein, ether extract, nitrogen-free-extract, total digestible nutrients and gross energy. An increase, as a result of the three preparations studied, is noted in the increased digestibility of the ether extract fraction of alfalfa hay. Because there does appear to be a general increase in all ration components, excepting crude fiber, the significant

TABLE IX. APPARENT DIGESTION COEFFICIENTS AS AFFECTED BY ROUGHAGE PREPARATION IN SHEEP AND CATTLE.

Ration:	D.M.	C.P.	E.E.	C.F.	N.F.E.	T.D.N.	Gross Energy
<u>Alfalfa Hay</u>							
<u>Long:</u>							
Reynolds & Lindahl (1960)	54.5	62.7	2.6	42.6	66.1	49.0	53.2
Reynolds & Lindahl (1960)	49.9	56.5	-4.8	40.0	61.1	42.7	47.9
Morrison (1959)		71.0	30.0	45.0	70.0	50.7	
Average	52.2	63.4	9.3	42.5	65.7	47.5	50.6
<u>Coarse Chop:</u>							
Price et al. (1963)	57.68	73.96	19.28	38.75	70.61	53.25	55.98
Meyer et al. (1959b)						58.70	60.62
Weir et al. (1959)		69.00		51.00		56.00	
Swanson & Herman (1952)	56.97	70.86	21.36	45.77	66.21	53.35	
Average	57.3	71.3	20.3	45.2	68.4	55.3	58.3
% Change	9.77	12.46	118.28	6.35	4.11	16.42	15.22
<u>Fine Chop:</u>							
Reynolds & Lindahl (1960)	57.6	68.2	-4.9	42.5	68.4	49.8	56.0
Reynolds & Lindahl (1960)	54.6	64.6	19.5	38.5	68.1	46.6	52.2
Reynolds & Lindahl (1959)	60.7	63.2	41.8	44.2	75.7	49.9	60.4
Swanson & Herman (1952)	57.28	72.54	21.06	44.72	67.06	53.48	
Average	57.6	67.1	19.4	42.5	69.8	50.0	56.2
% Change	10.34	5.84	108.6	0.00	6.24	5.26	11.07
<u>Pellet:</u>							
Price et al. (1963)	61.38	75.72*	16.33	39.77*	75.75*	58.5	60.25*
Meyer et al. (1959b)						59.5	62.79
Weir et al. (1959)		69.00		47.00*		55.0	
Reynolds et al. (1960)	56.5	68.4	54.0*	37.5*	68.1	49.1	54.9
Reynolds & Lindahl (1960)	55.0	65.8	22.9*	36.1*	69.9	46.8	52.6
Reynolds & Lindahl (1959)	61.4	63.7	59.4*	43.8	75.1	57.6	60.8
Average	58.6	68.5	38.2	40.8	72.0	54.4	58.3
% Change	12.26	8.04	310.75	-4.00	9.59	14.53	15.22

* ($P < 0.05$)

differences, as noted by the individual researchers, are noted by asterisks (*). Price et al. (1963), compared a coarse chopped and pelleted roughage, and noted increased digestion coefficients on crude protein, crude fiber, nitrogen-free-extract, and gross energy. Swanson and Herman (1952) detected no significant differences between coarse and fine ground alfalfa hay. Reynolds and Lindahl (1960) noted increased digestibility for ether extract and decreased digestibility for crude fiber. Reynolds and Lindahl (1959) reported an increased digestion coefficient for ether extract only when pelleted rations are fed. This is in agreement with the work of Weir et al. (1959). On this basis, it appears that the only significant effects of pelleting a roughage are to increase ether extract and decrease crude fiber digestibility. When data is limited on roughages other than alfalfa hay, Wallace et al. (1961) and Rodrigue and Allen (1960) reported digestion coefficients for meadow hay and grass hay-alfalfa mixtures. Wallace et al. (1961) stated that apparent digestibility of nutrients in chopped, wafered and pelleted meadow hay was not significantly different. Digestibility trends did, however, indicate a depression in dry matter, cellulose and energy digestion, and an increased crude protein digestion, as a result of pelleting. Rodrigue and Allen (1960) noted a depression in crude fiber digestion as a result of fine grinding with a grass hay-alfalfa mixture.

Blaxter and Graham (1956) studied the effects of feed preparation on energy utilization of dried grasses when fed to sheep in a coarse, medium and fine ground ration. It was reported that the method of preparation was without effect on net energy value for the dried grasses. Fecal energy losses were greater for sheep consuming both medium and fine ground hays,

and fecal losses increased as the daily intake increased. Methane production was highest on sheep getting the coarse chopped hay, and decreased as the daily intake was increased. Heat losses were greater for coarse chopped hays because the ground hays required no rumination and less eating time. The higher fecal losses of cubes were balanced by smaller losses of heat and methane, as compared to a chopped grass hay. Urinary losses of energy were unchanged as a result of feed preparation (Blaxter and Graham, 1956; Paladines et al., 1964).

The effects of pelleting mixed rations containing from 35 to 50 percent concentrates are shown in Table X. Results of this table are in accordance with results of Table IX. Results indicate an increased digestibility of the ether extract fraction and a decreased digestibility of the crude fiber fraction of mixed feeds as a result of pelleting.

Volatile Fatty Acids

The volatile fatty acids were reported to furnish from 40 to 100 percent of the resting energy requirements of ruminant animals (Hershberger et al., 1956). Investigations into the formation and metabolism of these important organic compounds were made by many workers. Hershberger et al. (1956) studied the effects of adding cellulose, starch and other metabolic intermediates upon formation of short chain fatty acids by rumen microorganisms. Hershberger et al. (1956) stated that glucose is the intermediate in the formation of volatile fatty acids from cellulose. Cellulose produced the volatile fatty acids at the following rate: Acetic > Propionic > Others. Carbon recovered as short chain fatty acids was 40 percent from cellulose and 50 percent from glucose. Acetate is a major precursor of

TABLE X. APPARENT DIGESTION COEFFICIENTS OF MIXED RATIONS

Mixed Ration-Unpelleted	D.M.	O.M.	C.P.	E.E.	C.F.	Cellulose	N.F.E.	T.D.N.
<u>35-50 percent Conc.</u>								
Bell <u>et al.</u> (1955)			62.03	50.53	52.18		80.35	62.12
Woods & Rhodes (1962)		71.30	73.10			50.30		
Bell <u>et al.</u> (1955)			65.84	63.65	50.52		83.32	65.75
Long <u>et al.</u> (1955)	68.50	69.10	62.80	63.20	46.50		77.80	
Esplin <u>et al.</u> (1957)	70.00			65.60	35.10		79.50	
Woods & Rhodes (1962)		79.90	73.70			50.70		
Average	69.3	73.4	67.5	60.7	46.1	50.5	80.2	63.9
<u>Mixed Ration-Pelleted</u>								
<u>35-50 percent Conc.</u>								
Bell <u>et al.</u> (1955)			66.37	62.07	25.77		83.06	61.52
Woods & Rhodes (1962b)		72.70	73.50			52.30		
Bell <u>et al.</u> (1955)			71.76	77.60	27.47		86.25	67.54
Long <u>et al.</u> (1955)	70.20	72.70	67.90	69.60		49.70	79.00	
Esplin <u>et al.</u> (1957)	69.50			64.50	31.70		78.40	
Woods & Rhodes (1962)		78.60	74.20			49.90		
Average	69.9	74.7	70.7	68.4	28.3	50.6	81.7	64.5
% Change	0.87	1.74	4.9	11.26	-38.61	0.32	1.87	0.93

butyrate and valerate (Van Campen and Matrone, 1961), while succinic acid produced, by rumen microorganisms, served as a precursor for propionic acid (Hershberger et al., 1956; Barnett and Reid, 1957). The volatile fatty acids are products primarily of the carbohydrate portions of ruminant rations; however, Davis et al. (1957) reported that dietary proteins are also precursors of volatile fatty acids.

The metabolism of fatty acids were studied by Pennington (1952). Butyric and acetic are ketogenic, are rapidly metabolized and serve the energy needs of the body. Both can enter the metabolic cycle of fat and thus form body fat. Propionic is glucogenic, and follows the same path in metabolism as glucose.

Ward et al. (1961) studied the concentrations of volatile fatty acids from five sections of the gastrointestinal tract of full fed beef heifers. Millimoles of volatile fatty acids per 100 ml. in samples from the rumen, abomasum, small intestine, ceacum and colon were 11.902, 1.292, 1.943, 12.155, and 11.214 respectively. Balch and Rowland (1957) studied the effects of various rations upon volatile fatty acid concentration. Only minor fluctuations in concentrations of total volatile acids were encountered on roughage rations alone. However, with concentrates, there is a rapid rise in total volatile fatty acid concentration in 2 to 6 hours following feeding. Acetic acid generally decreased in concentration with decreased roughage in the ration. Propionic, butyric and others are increased with increasing levels of concentrates. This phenomenon has also been recorded by Balch (1958) and Bensadoun et al. (1962).

Stewart et al. (1958) studied the rates of volatile fatty acid

production in the bovine rumen when hay was being fed. The average total rumen concentration of volatile fatty acids were reported to average 810 to 833 mg. The concentrations by weight were as follows: acetic 60 percent, propionic 18 percent, butyric 17 percent, and others 5 percent. Knox and Ward (1960) reported a relationship between the frequency of feeding and the amounts of volatile fatty acids being produced. Volatile fatty acids were significantly higher when the rations of cattle were divided into small portions and fed several times daily. Narrower acetic:propionic ratios were also noted.

Observations upon the effect of physical preparation of fattening rations on volatile fatty acids production have been studied by Woods and Luther (1962a), Rhodes and Woods (1962), Wright et al. (1963), and Knox et al. (1964). An increase in volatile fatty acid production, and a narrowing of the acetic:propionic ratio were noted when rations were ground, and a further increase was noted when rations were pelleted. The greatest change noted was an increase in the amounts of propionic acid produced (Shaw et al., 1960; Woods et al., 1962a; Rhodes et al., 1962; Wright et al., 1963; Knox et al., 1964; Johnson et al., 1964). Since propionic was increased, it is almost a universal opinion that propionic acid per se was responsible for increased gains and feed efficiency noted in pelleted rations. Based on the observations of Armstrong and Blaxter (1957a, 1957b, 1957c), Armstrong et al. (1958), and Davis et al. (1960), this would appear to be an erroneous statement.

The heat increment of carbohydrates in ruminants is caused by (1) bacterial fermentation, (2) metabolism of volatile fatty acids, (3) metabolism

of hexoses, and (4) the physical work of chewing and digestion. In often quoted work, Armstrong and Blaxter (1957a) stated that the heat losses for acetic acid is higher than the heat losses of propionic or butyric acids when given alone. The heat increment of acetic alone was reported by Armstrong and Blaxter (1957a) to represent approximately 23 percent of the energy of acetic acid. In often unquoted work, Armstrong et al. (1957b) reported the heat increment of propionic and butyric in 3:2 proportions to be 9 percent. Subsequent additions of acetic acid to this mixture resulted in only very small increases in the heat loss until the molar proportions of acetic exceeds 90 percent. When the molar proportions included 90 percent acetic acid, the heat increment represented 15 percent of the energy. On this basis, Armstrong et al. (1957b) stated that it is doubtful that differences in composition or preparation of rations per se and the volatile fatty acids resulting from altered fermentations could alter the heat increment of a ration significantly.

Thus, it cannot be stated that the increase of propionic acid per se is responsible for the increased performance noted when animal rations are ground or pelleted. The most logical explanation might then be a combination of factors. These include increased digestibility of some of the nutrient fractions of feedstuffs, decreased heat losses as a result of changes in proportions of volatile fatty acids, and finally, decreased energy normally used in physically preparing feedstuffs for digestion.

METHODS AND PROCEDURES

Trial I

Fifty head of Hereford steer calves were used in this fattening trial. Thirty-five head of the steers used were purchased at the Red Bluff Research Ranch at Norris, Montana. Fifteen of the steers were from the Les Holden Ranch at Valier, Montana. Ten steers were randomly assigned to one of five lots on the basis of weight and source. Three animals in each lot originated from the Les Holden Ranch, while seven of the animals originated from the Red Bluff Research Ranch.

Throughout this trial, the animals were located in a gravel-base loafing pen. In addition, the animals had access to a loafing shed, which was bedded liberally with wheat straw throughout the trial. Located within the loafing shed, and adjacent to the loafing area, was an open bunk used to feed long grass hay in this trial. Each lot of steers had access to fresh, unheated, running water from a tank located adjacent to the self-feeders in each lot.

The percent composition of the five pelleted concentrate rations in Trial I are given in Table XI. The pellets were made by Teslow, Inc., in Bozeman, and were 6.35 millimeters in diameter and approximately 2 centimeters long.

This trial was initiated by restricting each group of steers to their respective loafing sheds the night of December 14, 1962. Following a 16-hour shrink, they were individually weighed onto the fattening trial the morning of December 15, 1962. Individual, unshrunk weights were obtained at subsequent 28-day intervals.

At the start of the trial, each lot of cattle were group-fed, in open

TABLE XI. PERCENT COMPOSITION OF RATIONS FED IN TRIAL I.

Lot No.	2	1	5	4	3
MSC Formula	298	300	301	302	303
<u>Ingredient:</u>					
Barley, ground	40.0	-----	40.0	61.00	65.75
Barley, steam rolled	-----	40.0	-----	-----	-----
Wheat millrun	10.0	10.0	10.0	-----	-----
Oats	16.0	16.0	11.0	-----	-----
Beet pulp, D.M.	20.0	20.0	20.0	20.00	10.00
Cottonseed meal	2.5	2.5	-----	-----	-----
Soybean meal	2.5	2.5	-----	-----	-----
Safflower meal	-----	-----	10.0	10.00	10.00
Safflower hulls	-----	-----	-----	-----	5.00
Dehydrated alfalfa	2.5	2.5	2.5	2.50	2.50
Molasses	5.0	5.0	5.0	5.00	5.00
Dicalcium phosphate	0.5	0.5	0.5	0.75	0.75
Limestone	0.5	0.5	0.5	0.25	0.50
Salt	0.5	0.5	0.5	0.50	0.50
Trace mineral <u>1/</u>	X	X	X	X	X
Vitamin A & D <u>2/</u>	X	X	X	X	X
	100.0	100.0	100.0	100.00	100.00

1/ Trace mineral added at 908 gm. per ton.

2/ Vitamin A and D added to provide 4,400 I.U. of Vitamin A and 550 I.U. of Vitamin D per kilogram of feed.

bunks, an average of 2.27 kilograms per steer daily of their respective pelleted concentrate ration. In addition, each lot was group fed a mixed long grass hay on an ad libitum basis, and each steer was consuming an average of 3.64 kilograms of hay daily. The pelleted concentrate ration was increased by 0.46 kilogram per steer increments, until the end of the first 28-day period. At this time, each steer was consuming an average of 5.91 kilograms of the pelleted ration, and an average of 1.64 kilograms of long hay daily. At this time, the cattle were judged to be on full feed, and feeding the pelleted concentrate ration was accomplished by the use of

self-feeders located near the entrance to the loafing shed in each lot. Self-feeders were filled to capacity and for the remaining 212 days of the trial the cattle were self-fed the pelleted concentrate ration. Iodized salt was fed on an ad libitum basis throughout the trial.

Table XII presents the proximate chemical analysis of the feeds in Trial I.

TABLE XII. PROXIMATE CHEMICAL ANALYSIS OF FEED UTILIZED IN FATTENING RATION FOR BEEF CATTLE. 1/

Ration No.	Moisture	Crude Protein	Ether Extract	Ash	Crude Fiber	Cal- cium	Phos- phorus	Carotene mg./kg.	Gross Energy Kcal./kg.
300	9.5	13.3	2.7	4.6	8.4	0.73	0.45	----	3992
298	7.4	13.2	2.7	4.3	8.8	0.86	0.52	----	3721
303	7.3	12.4	2.2	4.4	11.3	0.86	0.47	----	3902
302	7.0	12.1	2.0	4.2	10.0	0.73	0.41	----	3951
301	7.0	12.9	2.5	4.7	10.9	0.59	0.41	----	3925
Hay	5.6	6.4	2.0	6.5	29.6	0.69	0.08	20.0	4093

1/ Unless otherwise designated, data is reported in percent.

At the termination of the trial, all cattle were again confined to their loafing sheds. At this time, all feed remaining in self-feeders was removed and weighed back. Following a 12-hour restriction from feed and water, all cattle were individually weighed and immediately loaded onto semi-trailers for transport to New Butte Butchering Company in Butte, Montana. Upon arrival in Butte, the cattle were unloaded and allowed poor quality grass hay and water ad libitum. The following day (August 13, 1963), the cattle were slaughtered as a group. As each animal was skinned, the ear tags were removed and the viscera and carcass identity were maintained. A record was made of the number of abscessed livers. The carcasses were weighed warm following shrouding and a pencil shrink (3 percent), was used

as an estimate of the cold carcass weight. No facilities were available to study the incidence or severity of Parakeratosis in Trial I.

On August 16, 1963, approximately 72 hours following slaughter, the carcasses were graded and a marbling score of the rib-eye at the 12th rib determined by a USDA grader. At this time, data on the rib-eye marbling score and backfat thickness at the 12th rib were also taken.

The final weights of the animals were subjected to statistical analysis of covariance, using initial weights as the concomitant variable. Other data was analyzed by analysis of variance or by Chi-square tests.

Trial II

Forty head of Hereford calves were used in this wintering trial. Twenty-eight head of the steers were produced at the Red Bluff Research Ranch located at Norris, Montana. Twelve of the Hereford steer calves were from the Kyd Cattle Company at Three Forks, Montana. Ten steers were randomly assigned to one of four lots on the basis of weight and source. Three animals in each lot originated from the Kyd Cattle Company. The remaining seven animals in each lot originated from the Red Bluff Research Ranch.

The alfalfa hay used in this trial consisted of excellent quality alfalfa hay originating from one field. One-half of the forage was long and baled, while the remaining one-half was wafered. The wafered hay was artificially dried and no mold or spoilage was noted in the wafered hay.

Wafers used in this trial measured 6.35 centimeters x 6.35 centimeters, and were approximately 10 centimeters in length.

The animals were maintained and fed in pens previously described in Trial I. All feed was fed in bunks located within and adjacent to the

loafing area in the barn.

On November 17, 1963, the calves were lotted to their respective lots and the animals were initiated to their respective feed treatments. Calves in each lot were group fed an average of 0.46 kilograms per steer of a concentrate mixture of 80 percent steam rolled barley and 20 percent dried beet pulp, in addition to long or wafered alfalfa hay fed on an ad libitum basis.

The concentrate ration was increased in uniform increments and when the calves were weighed at the initiation of the trial on November 26, 1963, they were consuming 0.91 kilograms per steer of the concentrate ration daily. Hay was fed ad libitum.

Table XIII presents data on the treatments used in this wintering trial. The calves were restricted to their individual loafing sheds, without access to feed and water.

TABLE XIII. TREATMENTS OF CALVES ON TWO LEVELS OF CONCENTRATES AND LONG OR WAFERED SECOND CUTTING ALFALFA HAY AS A WINTERING RATION.
(November 26, 1963, to February 17, 1964--84 days.)

Lot No.	1	2	3	4
No. Animals	10	10	10	10
Alfalfa Hay	Wafer	Long	Long	Wafer
<u>Conc. 1/(kg.)</u>				
1st period - 28 days	0.91	0.91	0.91	0.91
2nd period - 28 days	0.91	0.91	1.82	1.82
3rd period - 28 days	0.91	0.91	2.73	2.73
Average - 84 days	0.91	0.91	1.82	1.82
Salt and mineral	<u>ad lib.</u>	<u>ad lib.</u>	<u>ad lib.</u>	<u>ad lib.</u>
<u>1/ Concentrate: 80 percent steam rolled barley + 20 percent dried beet pulp.</u>				

Following a 12-hour shrink, individual initial weights were recorded the morning of November 26, 1963. Subsequent unshrunk individual weights were taken at 28-day intervals.

The rations in this trial were fed in equal portions twice daily. The ration was fed in the following sequence: concentrates, followed by hay, when the concentrates had been consumed. Hay was fed by limiting the hay intake of three lots to that amount consumed by the lot of steers in the lesser amount. Mineral and iodized salt were fed on an ad libitum basis. The composition of the mineral mixture used in this wintering trial is shown in Table XIV.

TABLE XIV. COMPOSITION OF MINERAL SUPPLEMENT USED IN WINTERING TRIAL FOR BEEF CALVES.

Ingredient:	Percent
Steamed bonemeal	33.3
Dicalcium phosphate	33.3
Iodized salt	33.4
Total	100.0

During the trial, an unusual number of bloating calves was observed. In an attempt to relieve the incidence of bloat, the concentrate ration was altered from 80 percent steam rolled barley and 20 percent beet pulp to a ration containing 50 percent steam rolled barley and 50 percent beet pulp. This alteration occurred on the 60th day of the wintering trial. The steers were maintained on the 1:1 barley-beet pulp ration for the remaining 25 days of the trial.

On the 65th day of the trial, the animals were fed a supplement containing a combination of antibiotics. This supplement was fed at the rate of

227 grams per head daily for the remaining 20 days of the trial. The composition of the antibiotic supplement used in this trial is shown in Table XV. This supplement was formulated to contain 308 milligrams of antibiotics per kilogram of supplement. The ration also contained 9.90 milligrams of a chemobiotic (Dynafac 20) per kilogram of supplement.

TABLE XV. SUPPLEMENT USED IN WINTERING RATION FOR STEER CALVES. (January 29, 1964, to February 17, 1964--20 days).

<u>Ingredient:</u>	<u>Percent</u>
Decorticated safflower meal (42)	50.5
Soybean oil meal	20.0
Dry molasses	5.0
Corn meal	20.0
Dehydrated alfalfa	2.5
Pen-strept 1/	0.6
Zinc bacitracin 2/	0.4
Dynafac 3/	1.0
Total	100.0

1/ Pen-strept: contains 11 mg. penicillin and 33 mg. streptomycin per kilogram.

2/ Zinc bacitracin: contains 44 milligrams zinc bacitracin per kilogram.

3/ Dynafac 20: 199.76 milligrams per kilogram.

On the evening of February 17, 1964, all calves were restricted to their respective loafing sheds, without access to feed and water. Following a 12-hour shrink, the calves were weighed individually and the weights recorded as final weights.

Final weights were subjected to statistical analysis by analysis of covariance using initial weights as the concomitant variable.

Trial III

Forty-five head of Hereford steer calves were used in this fattening trial. Thirty-one of these calves had been wintered on rations described

previously in Trial II and the remaining fourteen wintered on long grass hay ad libitum and an average of 1.82 kilograms of concentrates per head daily. Thirty-three steer calves used in this trial were produced at the Red Bluff Research Ranch at Norris, Montana, and the remaining twelve head of steers were purchased from the Kyd Cattle Company at Three Forks, Montana. Nine steers were randomly assigned to one of five lots on the basis of weight and source.

Throughout this trial, the animals were located in facilities as described previously for animals used in Trial I.

The percent composition of the five pelleted concentrate rations evaluated in Trial III are given in Table XVI. The pellets were made by Teslow, Inc., of Bozeman, Montana, and were 6.35 millimeters in diameter and approximately 2 centimeters in length.

This trial was initiated by restricting each group of cattle to their respective loafing sheds on the evening of February 21, 1964. Following a 16-hour shrink, without access to feed and water, the cattle were individually weighed onto the fattening trial the morning of February 22, 1964. Individual unshrunk weights were obtained at approximately 28-day intervals.

At the start of this trial, each lot of cattle were group fed in open bunks an average of 2.27 kilograms per head daily of their respective pelleted rations. In addition, each lot were group fed long grass hay on an ad libitum basis and were consuming 5.05 kilograms per head daily. The pelleted rations were increased in increments of 0.46 kilograms per head daily until the end of the first 28-day period. At this time, each steer was consuming 6.85 kilograms per day of the respective pelleted concentrate

ration and 3.03 kilograms daily of the long grass hay fed ad libitum. At this time, the cattle were judged to be on full feed. Self-feeders previously described in Trial I were filled with the respective concentrate rations and for the remaining 129 days of the feeding period, the cattle were self-fed the pelleted concentrate rations. Iodized salt, to which was added organic iodine, was furnished to the steer calves on an ad libitum basis throughout the trial.

TABLE XVI. PERCENT COMPOSITION OF RATIONS FED IN TRIAL III.

Lot No.	1	2	3	4	5
MSC Formula No.	375	376	377	378	379
<u>Ingredients:</u>					
Barley ground	40.5	23.0	35.5	18.0	40.5
Wheat millrun	10.0	10.0	10.0	10.0	10.0
Oats	17.5	35.0	17.5	35.0	17.5
Beet pulp, D.M.	20.0	20.0	20.0	20.0	20.0
Cottonseed meal	2.5	2.5	----	----	----
Soybean meal	2.5	2.5	----	----	----
Safflower meal (23%) <u>3/</u>	----	----	10.0	10.0	----
Safflower meal (43%) <u>4/</u>	----	----	----	----	5.0
Dehydrated alfalfa	2.5	2.5	2.5	2.5	2.5
Molasses	3.0	3.0	3.0	3.0	3.0
Dicalcium phosphate	0.5	0.5	0.5	0.5	0.5
Limestone	0.5	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5	0.5
Trace mineral <u>1/</u>	X	X	X	X	X
Vitamin A & D <u>2/</u>	X	X	X	X	X
Total	100.0	100.0	100.0	100.0	100.0

- 1/ Trace mineral added at 455 gm./metric ton.
- 2/ Vitamins A and D added to provide 4409 I.U. Vitamin A and 882 I.U. Vitamin D per kilogram of feed.
- 3/ Whole pressed safflower meal containing approximately 23 percent crude protein.
- 4/ Decorticated safflower meal containing approximately 43 percent crude protein.

Table XVII presents the proximate chemical analysis of feeds used in Trial III.

TABLE XVII. PROXIMATE CHEMICAL COMPOSITION OF FEEDS FED TO FATTENING STEERS. ^{1/}

Ration No.	Moisture	Crude Protein	Ether Extract	Ash	Crude Fiber	Phosphorus	Calcium	Carotene mg./kg.	Gross Energy Kcal./kg.
375	6.6	14.7	3.2	7.6	7.9	0.50	0.54	----	4172
376	6.4	14.8	3.5	7.5	9.5	0.48	0.46	----	4250
377	6.4	13.1	3.4	6.7	12.3	0.36	0.42	----	4135
378	6.3	13.3	3.1	7.3	13.4	0.39	0.40	----	4217
379	7.0	13.0	3.3	6.4	10.1	0.43	0.42	----	4093
Hay	5.2	8.1	2.5	8.3	30.4	0.14	1.36	20.9	4175

^{1/} Unless otherwise stated, all analyses are reported in percent.

On May 5, 1964, after 74 days on the trial, one calf in Lot 1 died of chronic bloat. This calf was replaced with a calf of similar weight and background obtained from a reserve lot. On May 9, 1964, 79 days after the initiation of the trial, a calf in Lot 2 was replaced because of chronic bloating, and a calf in Lot 3 was replaced because of an abscess on the leg of the animal. These calves were also replaced with animals of a similar weight and background. Records were adjusted accordingly when calves were replaced.

On the evening of July 27, 1964, the trial was terminated by restricting all cattle to their respective loafing sheds. Following a 16-hour shrink, without feed and water, individual final weights were recorded after 157 days on trial. All feed remaining in self-feeders was weighed back at this time. Immediately following the initial weights the cattle were loaded onto semi-trailers for transport to New Butte Butchering Company in Butte, Montana. Upon arrival in Butte the cattle were treated in a manner identical

to those cattle of Trial I. On July 29, 1964, the cattle were slaughtered as a group. As each animal was skinned, the ear tags were removed and the viscera and carcass identity were maintained. A record was made of condemned livers, and the entire rumen was examined for rumen parakeratosis.

On July 31, 1964, approximately 72 hours following slaughter, the carcasses were graded and a marbling score of the rib-eye at the 12th rib determined by a USDA grader. A tracing of the rib-eye at the 12th rib was also made at this time.

Statistically, the data collected in this trial were subjected to analyses identical to the data collected in Trial I.

RESULTS AND DISCUSSION

Trial I

The initial and final weights, average daily gains, average daily feed consumption and gross energy intake, and feed conversion data are presented in Table XVIII.

TABLE XVIII. SUMMARY OF WEIGHTS, AVERAGE DAILY GAINS, DAILY FEED CONSUMPTION AND GROSS ENERGY INTAKE, AND FEED CONVERSION OF CATTLE ON PELLETED CONCENTRATE RATIONS. (December 15, 1962 to August 12, 1963 -- 240 days).

Lot No.	1	2	3	4	5
MSC Formula No.	300	298	303	302	301
<u>Comparisons:</u>					
Barley ground	-	X	X	X	X
Barley steam rolled	X	-	-	-	-
Wheat millrun	X	X	-	-	X
CSM and SBOM	X	X	-	-	-
Safflower meal	-	-	X	X	X
Safflower hulls	-	-	X	-	-
No. Steers ^{1/}	10	9	10	8	10
<u>Avg. Wt. (kgs.):</u>					
Final	435.0	448.2	439.6	421.8	440.0
Initial	185.9	187.3	190.0	185.5	190.5
Gain	249.1	260.9	249.6	236.3	249.5
Daily gain	1.04	1.09	1.04	0.99	1.04
<u>Avg. Daily Ration (kg.):</u>					
Pellets	6.93	6.97	6.93	6.48	7.28
Grass hay	1.40	1.41	1.34	1.30	1.41
Salt	0.01	0.01	0.02	0.02	0.01
Total	8.34	8.39	8.29	7.80	8.70
<u>Avg. Gross Energy Consumed (Megacal/Day):</u>					
Pellets	27.67	25.94	27.04	25.60	28.57
Hay	5.73	5.77	5.48	5.32	5.77
Total	33.40	31.70	32.52	30.92	34.34
<u>Kg. Feed/Kg. Gain:</u>					
Pellets	14.68	14.10	14.67	14.47	15.38
Salt	0.01	0.02	0.03	0.03	0.02
Hay	2.97	2.86	2.84	2.91	2.98
Total	17.66	16.98	17.54	17.41	18.38

^{1/} One steer died of bloat in Lot 2 on June 27, 1963; one steer removed from Lot 4 on April 4, 1963, because of chronic bloat; one steer died in Lot 4 on July 13, 1963, from chronic bloat. Data on these steers were not used in calculating results.

Analysis of covariance of the gains of steers (Table XVIII) on the five pelleted rations indicated no significant differences ($P > 0.05$) due to treatment. This data would substantiate the earlier work (Baker et al., 1951; Hilston et al., 1951; Faulkner et al., 1952) that whole pressed safflower meal is a satisfactory source of protein for fattening cattle when fed to furnish the equivalent amount of crude protein furnished by other commonly used oil meal protein sources.

The gains of cattle in Lot 2, receiving a ground and pelleted barley, were comparable to the gains of steers in Lot 1, on a steam rolled and pelleted barley ration. On this basis, it would appear that the preparation of barley prior to the pelleting process has little effect upon the gains of cattle fed steam rolled and pelleted or ground and pelleted barley.

The addition of oats in the pelleted ration at 0, 11.0, and 16.0 percent of the ration, replacing ground or steam rolled barley, did not significantly alter the gains of the steers. Also, addition of wheat millrun as a substitute for barley in pelleted concentrate rations has not affected gains of the steers. This information indicates the addition of wheat millrun or oats as replacements for barley in pelleted rations for beef cattle would depend largely on the relative prices of the ration ingredients involved.

Addition of safflower hulls and ground barley to a ration replacing one-half of the beet pulp did not significantly alter gains of steers. These results indicated that safflower hulls are a satisfactory roughage substitute for beet pulp in steer fattening rations. It appears a choice of the two ingredients in fattening rations would depend upon the relative

costs of the two particular ingredients.

The average daily intake (Table XVIII) of the five pelleted rations would indicate no significant differences due to treatment. The animals were fed grass hay on an ad libitum basis, and based on the average daily rations all cattle consumed an average of 16 to 17 percent of the ration as long grass hay and 83 to 84 percent of the ration was consumed as the pelleted concentrate.

Feed conversion of the steers on the five pelleted rations were not significantly different in this trial (Table XVIII). Feed required per unit of gain was highest in the ration fed the calves in Lot 5 getting safflower meal as a protein source and lowest in steers in Lot 2 getting a combination soybean-cottonseed meal as protein source.

Table XIX shows carcass yields of the cattle on the five treatments in Trial I.

TABLE XIX. INDIVIDUAL CARCASS GRADES OF STEERS FED PELLETED CONCENTRATE RATIONS.

Treatment Lot No.	300 1	298 2	303 3	302 4	301 5
High choice	2	2	4	3	3
Avg. choice	5	2	4	2	2
Low choice	-	-	1	1	1
High good	2	1	-	-	4
Avg. good	1	3	1	2	-
Low good	-	1	-	-	-
Total	10	9	10	8	10

Chi-square test of the carcass grades indicates no significant differences ($P > 0.05$) due to treatment.

Table XX presents carcass data compiled and averaged for the five

treatments in Trial I. There were no statistically significant differences in any of the data studied.

TABLE XX. CARCASS DATA OF STEERS FED PELLETED CONCENTRATE RATIONS AS A FATTENING RATION.

Treatment	300	298	303	302	301
Lot No.	1	2	3	4	5
Carcass yields <u>1/</u>	58.4	58.9	57.8	58.6	58.9
Rib-eye (sq. cm./quintal)	26.61	26.04	26.04	27.45	27.45
Fat thickness 12th rib (mm.)	22.86	25.40	20.32	20.32	22.86
Marbling score <u>2/</u>	3.8	3.0	4.7	3.7	3.6
Avg. carcass grade <u>3/</u>	4.5	3.6	5.0	4.5	4.4
<u>Liver Data:</u>					
Condemned	5	7	6	3	6
Non-condemned	5	2	4	5	4

- 1/ Based on cold carcass weight (warm carcass minus 3 percent pencil shrink).
- 2/ Based on: small minus 1; small 2; small plus 3; moderate minus 4; moderate 5; moderate plus 6; high minus 7; high 8; high plus 9.
- 3/ Based on: high choice 6; average choice 5; low choice 4; high good 3; average good 2; low good 1.

Table XXI represents a summary of the expenses and returns of the cattle on pelleted concentrate rations in Trial I. Examination of Table XXI indicates a deficit between the total investment in the cattle and the gross return realized when the cattle were fed a pelleted ration. Rations showing the smallest deficit were fed to Lots 3 and 4 respectively. These rations contained safflower meal as a protein source and ground barley in place of wheat millrun and oats.

There were no statistically significant differences of any criteria studied due to treatment when cattle were fed pelleted concentrate rations in Trial I. Because pelleting a ration does involve an additional investment in rations for beef cattle, it is desirable to formulate a basic ration

TABLE XXI. SUMMARY OF EXPENSES AND RETURNS OF STEERS FATTENED ON PELLETTED ALL-CONCENTRATE RATIONS. (Trial I -- 240 days).

Treatment	300	298	303	302	301
Lot No.	1	2	3	4	5
No. Steers	10	9	10	8	10
<u>Avg./Steer:</u>					
Feed cost/quintal					
gain 1/	\$47.86	\$42.48	\$39.64	\$40.81	\$43.25
Gain (quintal)	2.491	2.609	2.496	2.363	2.495
<u>Financial Return</u>					
(Dollars)/Steer:					
Feed cost	119.22	110.83	98.94	96.43	107.91
Initial cost 3/	139.55	140.57	142.62	139.21	142.96
Total investment	258.77	251.40	241.56	235.64	250.87
Gross Return 2/	232.22	238.88	233.90	226.24	236.19
Net Return	-26.55	-12.52	-7.66	-9.40	-14.68

1/ Feed costs: Ration 300-\$6.72; Ration 298-\$6.17; Ration 303-\$5.51; Ration 302-\$5.75; Ration 301-\$5.75; Hay-\$2.20; Salt-\$3.57/ Quintal.

2/ Based on: \$92.5932/Quintal (\$42.00) choice, and \$89.2863/Quintal (\$40.50) good on carcass weight basis F.O.B. Bozeman, Montana.

3/ Based on: \$75.22/Quintal delivered Bozeman, Montana (\$34.12 cwt.).

in such a manner that this cost can be returned by increasing feed efficiency, gains and reducing waste and labor costs. Considering the data of Trial I, it is apparent that rations containing safflower meal as a protein source and ground barley as substitutes for wheat millrun and oats produced gains and feed efficiency in fattening cattle comparable to more complex rations. The costs of producing meat were less for the less complex rations, which economically would be important in overcoming the initial cost of pelleting.

Trial II

Table XXII presents the data of average daily gains and average daily feed consumption of the steer calves in Trial II, wintered on wafered or long, second cutting alfalfa hay and two levels of concentrates. Data on the weight gains of steer calves in the factorial experiment of Trial II

TABLE XXII. SUMMARY OF WEIGHT GAINS AND FEED CONSUMPTION OF HEREFORD STEER CALVES FED TWO LEVELS OF CONCENTRATES WITH LONG OR WAFERED ALFALFA HAY. (Trial II -- November 26, 1963 to February 17, 1964 -- 84 days).

Lot No.	1	2	3	4
<u>Treatment:</u>				
Hay	Wafered	Long	Long	Wafered
Concentrates				
avg. kg./day <u>1/</u>	0.91	0.91	1.82	1.82
Salt and mineral supp.	ad lib.	ad lib.	ad lib.	ad lib.
No. Steers	9 <u>2/</u>	9 <u>2/</u>	9 <u>2/</u>	8 <u>2/</u>
<u>Avg. Wts. (kg.)</u>				
Final	257.7	239.5	250.5	259.6
Initial	196.3	189.5	189.6	192.3
Gain	61.4	50.0	60.9	67.3
Avg. daily gain <u>3/</u>	0.73 ^a	0.59	0.72 ^b	0.80 ^{abc}
<u>Avg. Daily Ration (kg.)</u>				
Barley	0.65	0.65	1.21	1.21
Beet pulp	0.26	0.26	0.61	0.61
Supplement <u>4/</u>	0.05	0.05	0.05	0.05
Hay	5.19	5.21	4.28	4.28
Mineral	0.01	0.01	0.01	0.01
Salt	0.02	0.02	0.02	0.02
Total	6.18	6.20	6.18	6.18

1/ Steam rolled barley + beet pulp.

2/ One calf in each of Lots 1, 2 and 3, and two calves in Lot 4 died of bloat. Data on these calves were not used in calculating results of Trial II.

3/ (a) Gains of steers fed wafered hay were greater than steers fed long hay ($P < 0.05$).

(b) Gains of steers fed 1.82 kg./day concentrates were greater than steers fed 0.91 kg./day ($P < 0.05$).

(c) Steers in Lot 4 gained more than steers in Lot 2 ($P < 0.01$).

4/ Supplement used during last 20 days of trial as a carrier of antibiotics.

were analyzed by analysis of covariance. The gains of cattle fed the wafered second cutting alfalfa hay (Lots 1 and 4) were significantly greater ($P < 0.05$) than the gains of calves fed the long alfalfa hay (Lots 2 and 3). Wafering the second cutting alfalfa hay in this trial resulted in an increase in daily gain of 16 percent when compared to the same hay fed in the long form. This response is in close agreement with the literature reviewed and compiled in Table II where wafering increased daily gains by an average of 23 percent.

The steer calves fed an average of 1.82 kilograms of concentrates per day with long or wafered second cutting alfalfa (Lots 3 and 4) gained ($P < 0.01$) faster than did the calves (Lots 1 and 2) fed an average of 0.91 kilograms per day of the concentrates with long or wafered alfalfa hay. Feeding an average of 1.82 kilograms per day of concentrates (Lots 3 and 4) increased the gains of the steers by 9 percent when compared to steers fed an average of 0.91 kilograms of concentrates per day. The rations of steers in Lots 1 and 2 averaged 84 percent roughage, while ration fed the steers in Lots 3 and 4 averaged 69 percent roughage.

The steer calves in Lot 4, fed the wafered alfalfa hay and an average of 1.82 kilograms of concentrates, gained faster ($P < 0.01$) than did the calves fed long hay and an average of 0.91 kilograms of concentrates in Lot 2. Wafering the alfalfa hay and feeding the high level of concentrates to steers in this lot resulted in an increased average daily gain. This essentially is in agreement with the work of McCroskey *et al.* (1961) and with the literature compiled and averaged in Table IV.

Table XXIII presents data on the feed conversion and daily gross energy

intake of the steer calves in Trial II. There are no significant differences in the amount of feed required per unit of gain due to the four treatments in Trial II. The steers on wafered alfalfa hay required slightly less feed per unit of gain than steers fed long alfalfa hay. The steers fed an average of 1.82 kilograms of concentrates per day required less feed per unit of gain than the steers fed an average of 0.91 kilograms of concentrates per day. Wafering the alfalfa resulted in a 14 percent decrease in the amount of feed required per unit of gain, which is in close agreement with the results of Table II where wafering resulted in a 9 percent decrease in feed required per unit of gain.

Calculated on an "as fed" basis, the gross energy intake for the steers are presented in Table XXIII.

TABLE XXIII. FEED CONVERSION AND DAILY GROSS ENERGY INTAKE OF HEREFORD STEER CALVES ON TWO LEVELS OF CONCENTRATES AND WAFERED OR LONG ALFALFA HAY AS A WINTERING RATION.

Lot No.	1	2	3	4
<u>Kg. Feed/Kg. Gain</u>				
Barley	1.94	2.39	3.68	3.33
Beet pulp	0.79	0.97	1.85	1.66
Supplement	0.16	0.19	0.16	0.16
Hay	15.64	19.26	12.97	11.70
Mineral	0.01	0.01	0.01	0.01
Salt	0.06	0.06	0.05	0.05
Total	18.60	22.88	18.72	16.91
<u>Avg. Gross Energy Intake/ Day (Megacal.)</u>				
Barley	2.75	2.75	5.12	5.12
Beet pulp	1.02	1.02	2.39	2.39
Hay	21.37	21.44	17.62	17.62
Total	25.14	25.21	25.13	25.13

When calculated on an "as fed" basis, there were no significant

differences in the average gross energy intake per day. Steers in all lots consumed daily an average of slightly more than 25 megacalories. No data are available on daily gross energy calculated on an "as consumed" basis, but on an "as consumed" basis, the gross energy values would be lower for calves consuming the long alfalfa hay. More long alfalfa hay was wasted. The long alfalfa hay was of an excellent quality, and at no time during the trial was this loss greater than could be expected when feeding long hay. Loss of the wafered alfalfa hay as calves consumed feed during this trial was negligible.

Table XXIV presents data on the proximate chemical analysis of the feeds utilized in Trial II. Examination of Table XXIV would indicate only slight differences in the chemical composition of long or wafered alfalfa hay for all fractions except carotene. The amount of carotene in the wafered alfalfa hay (52.0 mg./kg.) is approximately one-half that in the baled alfalfa hay (101.0 mg./kg.). It is apparent that there was considerable destruction of carotene in the wafering process. It is logical to

TABLE XXIV. PROXIMATE CHEMICAL ANALYSIS OF FEED UTILIZED AS A WINTERING RATION FOR STEER CALVES. 1/

Ingredient	Mois- ture	Crude protein	Ether extract	Ash	Crude fiber	Cal- cium	Phos- phorus	Carotene mg./kg.	Gross Energy Kcal./kg.
Wafered alfalfa	6.5	17.6	1.2	11.5	28.6	1.32	0.21	52.0	4117
Long alfalfa	7.1	19.0	1.0	10.7	26.8	1.19	0.19	101.0	4116
St. rolled barley	8.2	10.9	1.3	7.6	5.1	0.05	0.34	-----	4233
Beet pulp	6.0	10.0	0.2	8.2	17.7	1.42	0.08	-----	3926
Supplement	1.2	33.7	2.0	8.5	12.6	0.29	0.35	-----	-----

1/ Unless otherwise stated, all analyses are reported in percent.

assume that the heat and pressure exerted on the alfalfa in the wafering process was responsible for the oxidation or destruction of the carotene in the hay. A similar report has been made by Haenlein (1962).

Table XXV presents data on the general health of animals in Trial II fed wafered or long alfalfa hay and two levels of concentrates during a wintering trial. The incidence of chronic bloating was high during this trial. This condition was particularly prevalent in Lot 4 on calves receiving the wafered alfalfa hay and an average of 1.82 kilograms of concentrates daily. An increased level of concentrate feeding seemed to aggravate this condition during the second period (28 days) when the calves in Lots 3 and 4 respectively were increased to 1.82 kilograms concentrate daily. During the second period, two calves, one each in Lots 2 and 4 were lost to bloat while unattended during the night. During the first part of the third period another calf in Lot 4 was lost with chronic bloat. On January 24, 1964, the concentrate ration was altered to include more beet pulp (50 percent barley and 50 percent beet pulp) in an attempt to reduce the incidence of bloat. Following this alteration in concentrate feeding, one steer in each of Lots 1 and 2 were lost due to chronic bloating and an antibiotic supplement was used to reduce the chronic bloating. During the last 20 days of the trial, an antibiotic supplement containing 308 mg. of a mixture of antibiotics and 9.90 gm. of a chemobiotic (Dynafac 20) per kilogram of supplement was fed at the rate of 227 gm. per head daily. After the inclusion of the antibiotic supplement, no further occurrence of chronic bloating occurred until February 15, 1964, when one calf in Lot 4 bloated. The incidence of bloat was reduced, making it possible to continue the wintering

TABLE XXV. INCIDENCE OF BLOAT AND FOOTROT IN BEEF CALVES ON A WINTERING RATION OF LONG OR WAFERED ALFALFA HAY AND TWO LEVELS OF CONCENTRATES.

Lot No.	1	2	3	4	Remarks: Condition and Date
Treatment:					
Hay	Wafer	Long	Long	Wafer	
Conc. (kg./day					
avg.) <u>2/</u>	0.91	0.91	1.82	1.82	
Salt & mineral	ad lib.	ad lib.	ad lib.	ad lib.	
No. Steers					
(Nov. 26, 1963)	10	10	10	10	
<u>1st Period-28 days</u>					
Steer No. 382				X	Footrot 12/21/63
330				X	Bloat 12/22/63
401		X			Bloat 12/22/63
<u>2nd Period-28 days</u>					
Steer No. 407				X	Bloat 12/30/63
335				X	Bloated & died 12/31/63 <u>1/</u>
304				X	Bloat 12/31/63
376			X		Bloat 1/2/64
330				X	Bloat 1/3/64
383			X		Bloat 1/4/64
402			X		Bloat 1/7/64
409		X			Bloated & died 1/20/64 <u>1/</u>
<u>3rd Period-28 days</u>					
Steer No. 314				X	Bloated & died 1/23/64 <u>1/</u>
339				X	Bloat 1/23/64
Ration altered: 50% steam rolled					
barley + 50% beet pulp					1/24/64 <u>2/</u>
307			X		Bloated & died 1/27/64 <u>1/</u>
365	X				Bloated & died 1/28/64 <u>1/</u>
Ration altered: antibiotic supplement added <u>3/</u>					1/29/64
330				X	Bloat 2/15/64
<u>Animals on trial</u>					
after 84 days <u>4/</u>	9	9	9	8	

1/ Died of bloat while unattended at night.

2/ Original ration consisted of 80 percent steamed rolled barley and 20 percent beet pulp. Altered on January 24, 1964, to 50 percent steamed rolled barley and 50 percent beet pulp.

3/ Antibiotic supplement containing 308 mg. antibiotics/kg. and 9.90 gm. Chemobiotic (Dynafac 20)/kg.

4/ All data presented in Trial II were based on averages of calves remaining on trial after 84 days.

trial for an 84-day feeding period.

Table XXVI represents a summary of expenses and estimated net returns of steer calves following an 84-day wintering trial when steer calves were fed wafered or long alfalfa hay and two levels of concentrates.

TABLE XXVI. SUMMARY OF EXPENSES AND ESTIMATED RETURNS OF STEER CALVES WINTERED ON LONG OR WAFERED ALFALFA HAY AND TWO LEVELS OF CONCENTRATES. (Trial II -- 84 days)

Lot No.	1	2	3	4
<u>Treatment:</u>				
Hay	Wafer	Long	Long	Wafer
Conc. (Kg./day avg.)	0.91	0.91	1.82	1.82
Salt and mineral	ad lib.	ad lib.	ad lib.	ad lib.
No. Steers	9	9	9	8
Feed cost/quintal gain (\$) <u>1/</u>	22.77	28.00	26.10	23.57
Gain (quintals)	0.614	0.500	0.609	0.673
<u>Financial Return</u> <u>(Dollars)/Steer:</u>				
Feed cost <u>4/</u>	13.98	14.00	15.89	15.86
Initial cost <u>2/</u>	120.98	116.76	116.76	118.44
Total investment	134.96	130.76	132.65	134.30
Estimated Gross Return <u>3/</u>	147.42	137.02	143.26	148.46
Estimated Net Return	12.46	6.26	10.61	14.16

1/ Quintal equals 220.46 pounds.

2/ Based on \$61.73/quintal (\$28.00 cwt.).

3/ Based on \$57.32/quintal (\$26.00 cwt.).

4/ Based on: antibiotic supplement-\$13.93; beet pulp-\$4.37; steam rolled barley-\$4.96; hay-\$2.20; iodized salt-\$3.58; mineral supplement-\$8.64/quintal.

In Table XXVI the cost for either wafered or long alfalfa hay was based on a price of \$22.05 a metric ton for hay. Based on estimated costs of wafering, drying and transportation of the wafered hay (Holekamp, 1964), the cost of the wafered hay would be \$24.69 a metric ton. This cost was

estimated on the basis that the wafering machine was operated for 300 hours per season and was producing 1.8 metric tons per hour of wafered hay. Feed costs per unit of gain and estimated net returns calculated on the basis of the wafered hay at \$24.69 a metric ton increases only slightly the feed cost and decreases slightly the estimated net returns. These figures, however, do not significantly alter the results of Table XXVI when the hay costs were based on a cost of \$22.05 a metric ton.

The data in Table XXVI show the wafered alfalfa hay, when fed with an average of 0.91 kilograms of concentrates per day, was the most economical ration with respect to converting feed into gain. Increasing the level of concentrates in the ration to an average of 1.82 kilograms per day, when fed with wafered alfalfa hay, increased the feed cost per unit of gain slightly. Feed cost per unit of gain was highest for steers in Lot 2, fed the long alfalfa hay and an average of 0.91 kilograms per day of the concentrate ration. Increasing the concentrates to an average of 1.82 kilograms per day, when fed the long alfalfa hay, decreased this cost slightly. On the basis of this trial, it is apparent that feeding the alfalfa hay in the wafered form resulted in the most economical costs per unit of gain, when compared to the long alfalfa hay. Increasing the level of concentrate feeding from 0.91 kilograms to 1.82 kilograms per day would result in only a slight decrease in feed cost per unit of gain.

Following the wintering trial, the cattle were randomly reallocated and initiated onto a fattening trial (Trial III). Identity of these cattle were maintained, however, and following a 157-day fattening trial, the gains of the steers were analyzed by analysis of covariance to test the effects

of the wintering rations upon subsequent gains during the fattening trial. This data (Table XXVII) would indicate that cattle fed an average of 0.91 kilograms of concentrates per day, and either long or wafered alfalfa hay, gained faster ($P < 0.01$) than the steers fed an average of 1.82 kilograms of concentrates and long or wafered alfalfa hay in the wintering ration.

TABLE XXVII. SUMMARY OF WEIGHTS OF CATTLE FED A PELLETTED CONCENTRATE FOLLOWING A WINTERING RATION OF LONG OR WAFERED ALFALFA HAY AND TWO LEVELS OF CONCENTRATES. (Wintering Trial -- 84 days; Fattening Trial -- 157 days).

Lot No.	1	2	3	4
<u>Wintering Treatment:</u>				
Hay	Wafer	Long	Long	Wafer
Conc. (kg./day avg.)	0.91	0.91	1.82	1.82
Salt and mineral	ad lib.	ad lib.	ad lib.	ad lib.
<u>Avg. wts. during fattening trial (kg.)</u>				
Final	433.6	415.0	415.0	425.5
Initial	254.5	246.8	250.5	257.3
Gain	179.1	168.2	164.5	168.2
Avg. daily gain ^{1/}	1.14	1.12	1.05	1.07

^{1/} Gains of steers fed long or wafered hay and 0.91 kg./day of concentrates during a wintering trial were significantly higher ($P < 0.01$) during a subsequent fattening trial.

The data of Trial II would indicate a definite advantage in response, as measured by weight gains and net returns of steer calves wintered on the wafered alfalfa hay. This increased response is logically due to slight increases in the digestibility of some of the nutrient fractions, slight decreases in heat losses, as a result of changes in proportions of volatile fatty acids, and finally, decreases in the energy normally used in physically preparing the wafered hay for digestion. Increasing the level of concentrate feeding from an average of 0.91 to 1.82 kilograms per day also

increases daily gain. This response is logically due to slight increases in the net energy intakes of the steer calves, when the concentrate levels were increased. This increase in net energy would amount to approximately 0.5 megacalories per day, as calculated from the energy values of Morrison (1959).

When the subsequent gains of the cattle were analyzed following a 157-day fattening period (Trial III), the data indicates the gains of steer calves wintered on 0.91 kilograms of concentrates and long or wafered alfalfa hay were greater than the steers fed concentrates at an average of 1.82 kilograms per day with long or wafered hay. Based on overall gains in a wintering and subsequent fattening period, wafered hay and concentrates fed at an average of 0.91 kilograms per day during the wintering period, resulted in a greater response in daily gains than feeding 1.82 kilograms of concentrates daily and either long or wafered hay.

Trial III

The initial and final weights, average daily gains, feed conversion, average daily ration and daily gross energy intake data are summarized for Trial III in Table XXVIII. Analysis of covariance of gains of the cattle fed the pelleted concentrate rations and long grass hay on an ad libitum basis indicates no significance differences ($P > 0.05$) due to treatment.

No correlation between the level of oats in the ration can be detected in the gains of the steers in this trial. These results would be in agreement with the results of Trial I where no significant correlation between the levels of oats in the pelleted rations and gains of steers could be detected. On the basis of data from Trials I and II, it would appear that

addition of oats to fattening rations as a replacement for barley depends upon the relative costs of the ingredients involved.

TABLE XXVIII. SUMMARY OF INITIAL AND FINAL WEIGHTS, AVERAGE DAILY GAINS, FEED CONVERSION, AVERAGE DAILY RATION, AND DAILY GROSS ENERGY INTAKE OF STEERS FED PELLETTED CONCENTRATE RATIONS.
(Trial III -- February 22, 1964 to July 28, 1964 -- 157 days).

Lot No.	1	2	3	4	5
Rations MSC No.	375	376	377	378	379
<u>Comparisons:</u>					
CSM + SBOM	X	X			
Safflower (23)			X	X	
Safflower (43)					X
Oats (% Ration)	17.5	35.0	17.5	35.0	17.5
No. Steers/Lot	9	9	9	9	9
<u>Avg. Wt. (kg.)</u>					
Final	420.0	406.4	423.7	419.1	421.8
Initial	253.1	246.8	248.1	244.9	246.8
Gain	166.9	159.6	175.6	174.2	175.0
Avg. daily gain	1.06	1.02	1.12	1.11	1.12
<u>Kg. Feed/Kg. Gain</u>					
Pellets	14.73	14.49	15.17	14.49	13.72
Hay	4.72	4.91	4.57	5.29	4.39
Salt	0.02	0.02	0.02	0.02	0.02
Total	19.47	19.42	19.76	19.80	18.13
<u>Avg. Daily Ration (kg.)</u>					
Pellet	7.16	6.70	7.74	7.30	6.94
Hay	2.30	2.27	2.34	2.67	2.22
Salt	0.01	0.01	0.01	0.01	0.01
Total	9.47	8.98	10.09	9.98	9.17
<u>Avg. Gross Energy Intake</u>					
<u>Megacal./Day</u>					
Pellet	29.87	28.47	32.00	30.78	28.41
Hay	9.62	9.48	9.77	11.15	9.27
Total	39.49	37.95	41.77	41.93	37.68

The addition of whole pressed safflower meal or decorticated safflower meal, as a replacement for cottonseed and soybean meal as protein sources, had no significant effects upon daily gains of steers. The gains of cattle

in this trial were slightly greater when safflower meal was used as a protein source, as compared to steers fed a combination soybean and cottonseed meal. The results of this trial and of Trial I would substantiate the work of Baker et al. (1951) and Hilston et al. (1951) who reported that safflower meal can replace soybean and cottonseed meal as protein sources when fed to furnish an equal amount of protein.

Table XXVIII presents data on feed conversion, average daily feed consumption and calculated data on the daily gross energy intake of the steers fed the pelleted concentrate rations. Data in Table XXVIII would indicate very slight differences in the amounts of feed required per unit of gain due to treatments in this trial. The ration fed steers in Lot 5, containing the decorticated safflower meal, required the least amount of feed per unit of gain.

The average daily feed consumption data in Table XXVIII would indicate only slight differences in daily feed consumption. In this trial, the steers were fed hay on an ad libitum basis and they selected a ration containing from 23 to 27 percent roughage.

Table XXIX presents carcass data of the steers in Trial III. Statistical analysis of data in Table XXIX indicates the differences were not significant. Carcass grades, yields, and backfat were lowest in steers fed cottonseed and soybean oil meal as the protein source, and oats, at 35 percent of the ration, replacing ground barley.

At slaughter, a visual estimate was made of the incidence of rumen parakeratosis of the cattle. Table XXX presents this data. This information would not indicate any correlation between the incidence and severity

TABLE XXIX. CARCASS DATA OF STEERS FED PELLETTED CONCENTRATE RATIONS IN A FATTENING RATION.

Lot No.	1	2	3	4	5
<u>Individual Carcass Grades:</u>					
High choice			1	1	
Average choice	2	6	3	2	3
Low choice	6		5	5	6
High good				1	
Average good		2			
Low good	1	1			
Carcass yield % (avg.) <u>1/</u>	59.4	58.0	58.3	59.1	59.3
Rib eye 12th rib					
sq. cm./quintal <u>2/</u>	26.45	26.45	26.00	26.32	26.45
Fat thickness					
12th rib (mm.)	19.24	15.42	19.33	19.78	16.97
Marbling score 12th rib	6.0	6.2	6.2	5.4	6.0
Condemned livers	4	7	5	3	3
Non-condemned livers	5	2	4	6	6

1/ Based on warm carcass weight minus 3 percent pencil shrink.

2/ Loin eye area at 12th rib/quintal of shrunk carcass.

TABLE XXX. SUMMARY OF OCCURRENCE OF RUMEN PARAKERATOSIS OF STEERS FATTENED ON PELLETTED CONCENTRATE RATIONS AND FED LONG HAY AD LIBITUM. 1/

Lot No.	1	2	3	4	5
	0	0	0	0	0
	0	0-25	0-25	----	25-50
	0-25	0-25	0-25	0-25	0
	0-25	0-25	0	0	0
	0	0	0-25	0	0-25
	0	0-25	0-25	0	0-25
	0	0	0-25	0	0
	0	0	0-25	0-25	0
	0-25	----	----	0-25	0-25

1/ Based on percentage of total area of rumen affected.

of rumen parakeratosis and the performance of steers on the pelleted concentrate rations. This information is in agreement with data reported by Jordan (1959) and Garrett et al. (1961) where long hay fed with pelleted concentrate rations reduced the incidence and severity of rumen parakera-

tosis.

Table XXXI presents a summary of financial returns of steers fed pelleted concentrate rations in Trial III. Feed costs per unit of gain were lowest when safflower meal was used as a protein replacement for a combination of soybean and cottonseed oil meal. The feed costs per unit of gain were lower for the decorticated safflower meal than for rations containing the whole pressed safflower meal. Cattle fed safflower meal as a protein source, in general, made greater gains and the net returns were greater than for cattle fed a combination soybean-cottonseed oil meal supplement. This data is in agreement with the results of Trial I.

TABLE XXXI. SUMMARY OF FINANCIAL DATA OF CATTLE FED PELLETED CONCENTRATE RATIONS.

Lot No.	1	2	3	4	5
Treatment	375	376	377	378	379
<u>Averages/Steer:</u>					
Feed cost/quintal					
gain (\$) <u>1/</u>	46.14	45.97	45.59	44.60	42.81
Gain (quintal)	1.669	1.597	1.755	1.742	1.751
Initial cost (\$) <u>2/</u>	145.08	141.44	142.22	140.40	141.44
Feed cost (\$)	77.01	73.41	80.01	77.69	74.96
Total investment (\$)	222.09	214.85	222.23	218.09	216.40
Gross return (\$) <u>3/</u>	203.10	190.62	201.32	201.59	204.20
Net return (\$)	-18.99	-24.23	-20.91	-16.50	-12.20

1/ Based on: Ration 375-\$6.20; Ration 376-\$6.24; Ration 377-\$5.95; Ration 378-\$5.97; Ration 379-\$6.17; Hay-\$2.20; Salt-\$3.57/quintal.

2/ Initial cost \$57.32/quintal (\$26.00 cwt.).

3/ Sold on carcass grade basis: Choice-\$81.57/quintal (\$37.00/cwt.) and Good-\$79.36/quintal (36.00/cwt.).

Examination of the financial data would indicate no correlation between the level of oats in the pelleted rations and feed costs per unit of gain on

the net return.

Examination of results of Trial III would indicate that whole pressed safflower meal or decorticated safflower meal are protein sources, comparable to combinations of soybean and cottonseed meal, when fed in pelleted rations for fattening beef cattle. Replacing ground barley with oats appears to be of little advantage in fattening rations for beef cattle.

SUMMARY AND CONCLUSIONS

For a period of 240 days (Trial I) or 157 days (Trial III), a total of ninety-two Hereford steers were fed a fattening ration of pelleted concentrates consisting of various combinations of feeds common to, or of economic importance to, the State of Montana. Long grass hay and salt were fed ad libitum with the pelleted rations in both trials.

Prior to the initiation of the trial, the Hereford steers were weighed for allotment to their treatment. They were then stratified according to weight and source and randomly allotted to their respective treatment. In Trial I the animals were allotted into five lots of 10 animals each, while in Trial III the animals were allotted into five lots of nine animals each. Initial and final weights of all animals were obtained following an approximate 14-hour shrink without access to either feed or water.

Studied in this experiment were the effects of self-feeding pelleted concentrate rations, containing combinations of feedstuffs, with long grass hay ad libitum. The criteria studied were weight gains, feed efficiency, feed consumption, carcass grades and yields, rib-eye area and marbling score, fat thickness, liver condemnation, incidence of rumen parakeratosis, and the net returns of animals fed pelleted concentrate rations. Statistically, there were no significant differences due to treatment in any of the data collected.

Decorticated and whole pressed safflower meal, as protein sources for fattening steers, produced gains comparable to a combination of soybean meal and cottonseed meal when fed on an equivalent protein basis. There were no significant differences in either trial in the amount of feed required per unit of gain, nor in the average daily feed consumption.

The gains of steers fed ground and pelleted barley (Trial I) were slightly greater than the gains of steers fed a steam rolled and pelleted barley. This difference was not statistically significant, and it would appear that preparation of barley prior to the pelleting process has little effect upon the gains of cattle fed steam rolled and pelleted or ground and pelleted barley.

Replacing ground barley in pelleted concentrate rations with various levels of oats (0, 11 and 16 percent in Trial I and 17.5 and 35.0 percent in Trial III) has no effect upon subsequent performance of fattening cattle. Gains were slightly in favor of cattle fed oats as a replacement for ground barley in Trial I, and there was no effect on gains of steers in Trial III when ground barley was replaced with 17.5 or 35.0 percent oats. Addition of wheat millrun as a partial substitute would likewise be of a small benefit.

Gains of steers fed a ration with safflower hulls and ground barley, replacing one-half of the beet pulp, were similar to a ration containing no safflower hulls. This indicates that safflower hulls are a satisfactory roughage substitute for beet pulp in steer fattening rations.

In both trials (Trial I and Trial III), there were no significant differences due to treatment in any carcass data collected. Average carcass grades, rib-eye area, marbling score, or fat thickness showed no consistent improvements or depression when various combinations of pelleted concentrate feeds were fed.

Examination of the total rumen of steers fed pelleted concentrate rations and long grass hay (Trial III) showed a low incidence of rumenitis.

Feeding long grass hay ad libitum with the pelleted concentrate ration has proven effective in reducing the incidence and severity of ruminal parakeratosis.

Feed costs per unit of gain were lowest and net returns highest when the rations contained safflower meal as the protein supplement and when ground barley was substituted for wheat millrun, oats and beet pulp. Because pelleting a ration does involve an additional investment in rations for beef cattle, it is desirable to formulate a basic ration in such a manner that this cost can be returned by increasing feed efficiency, gains, and reducing waste and labor costs. Considering the data of Trials I and III, it is apparent that rations containing safflower meal as a protein source, and ground barley as substitutes for wheat millrun and oats, produced gains and feed efficiency in fattening cattle comparable to more complex rations. The costs of producing meat was less for the less complex rations, which economically would be important in overcoming the initial cost of pelleting.

In Trial II forty head of Hereford steer calves were fed for 84 days on a wintering ration of wafered or long alfalfa hay and two levels of concentrates. Prior to the initiation of this wintering trial, the Hereford steer calves were weighed for allotment to their respective treatments. They were stratified according to weight and source and randomly allotted to their respective treatments. Ten animals were allotted to each of four lots. Initial and final weights of all animals were obtained following an approximate 14-hour shrink without access to feed or water.

Studied in this experiment were the effects of feeding long or wafered

second cutting alfalfa hay and two levels (0.91 or 1.82 kg./day) of concentrates. The criteria studied were weight gains and feed efficiency of steer calves during the wintering period (Trial II), and the subsequent weight gains of the steers in a fattening period (Trial III).

The gains of the steers fed the wafered second cutting alfalfa hay were significantly greater ($P < 0.05$) than gains of steer calves fed long alfalfa hay. Wafering of the alfalfa hay resulted in a 16 percent increase in daily gains of these steer calves.

The steer calves fed an average of 1.82 kilograms of concentrates and either long or wafered alfalfa hay gained significantly faster ($P < 0.01$) than did the calves fed an average of 0.91 kilograms of concentrates daily. The increased level of concentrate feeding resulted in a nine percent increase in daily gains of the animals.

There was no significant differences in the amounts of feed required per unit of gain. The steers fed the wafered alfalfa hay required slightly less feed per unit of gain than the steers fed long alfalfa hay. Steers fed an average of 1.82 kilograms of concentrates per day required slightly less feed per unit of gain than steers fed an average of 0.91 kilograms of concentrates per day. Wafering the alfalfa hay resulted in a 14 percent decrease in the amount of hay required per unit of gain.

The chemical analysis of wafered and long alfalfa hay would indicate only slight differences in all nutrient fractions of the two hays, except for carotene. Wafered alfalfa hay contains about one-half as much carotene as the long alfalfa hay. Heat and pressure exerted on the alfalfa hay in the wafering process was likely responsible for this reduction in carotene.

Feed costs per unit of gain during the wintering period were lowest when wafered alfalfa hay and an average of 0.91 kilograms concentrates per day were fed. Feed costs per unit of gain were lowest when calves were fed wafered alfalfa hay. Increasing the level of concentrates increased slightly the feed costs when wafered hay was fed, but decreased the costs slightly when long alfalfa hay was fed.

Estimated net returns of the steer calves were significantly higher for calves fed the wafered alfalfa hay. Increasing the level of concentrates in the daily ration resulted in only slight increases in the estimated net return of the steer calves.

Following the wintering trial (Trial II) the calves were used in a fattening trial previously described (Trial III). Identity of calves used in the wintering trial was maintained to test the effects of the wintering treatment upon the subsequent gains of cattle in the feedlot. This data indicated that calves fed either long or wafered alfalfa hay and an average of 0.91 kilograms of concentrates daily gained significantly faster ($P < 0.01$) than calves wintered on wafered or long alfalfa hay and 1.82 kilograms of concentrates daily. Based on the entire data of Trial II and subsequent performance of cattle in the feedlot, it was apparent that feeding concentrates at the 0.91 kilograms per day level with wafered alfalfa hay resulted in the highest performance of steers.

APPENDIX

APPENDIX TABLE I. METRIC AND ENGLISH EQUIVALENTS.

Linear Measure

10 millimeters (mm.)	=	1 centimeter (cm.)
10 centimeters	=	1 decimeter (dm.)
10 decimeters	=	1 meter
1 inch (in.)	=	2.54 centimeters
1 foot (ft.)	=	0.3048 meter
1 yard (yd.)	=	0.9144 meter

Square Measure Equivalents

1 square inch	=	6.452 square centimeter
1 square foot	=	0.0929 square meter
1 square yard	=	0.8361 square meter

Weight-Measure Equivalents

1 kilogram (kg.)	=	1000 grams (gm.)
1 kilogram	=	2.2046 pounds (Avoir.)
1 quintal	=	220.46 pounds
1 metric ton	=	2204.6 pounds

APPENDIX TABLE II. INITIAL, FINAL AND GAINS OF INDIVIDUAL STEERS FED PELLETED CONCENTRATE RATIONS. (Trial I -- December 15, 1962 to August 27, 1963 -- 240 days). 1/

Lot No. (Treatment) 1 (300)

<u>Steer No.</u>	<u>Initial</u>	<u>Final</u>
9	420	950
25	465	1040
36	475	1035
202	495	1060
207	425	865
226	360	795
339	345	900
247	320	960
248	385	975
253	395	990

Lot No. (Treatment) 2 (298)

<u>Steer No.</u>	<u>Initial</u>	<u>Final</u>
6 2/	450	917 1/
17	430	1040
94	465	1005
213	485	1060
214	435	1000
219	390	920
225	375	990
228	380	965
236	415	1015
245	330	875

Lot No. (Treatment) 3 (303)

<u>Steer No.</u>	<u>Initial</u>	<u>Final</u>
18	490	1150
40	425	1055
46	450	910
205	445	1020
211	340	835
222	410	920
223	460	1025
238	420	905
241	395	925
261	340	920

Lot No. (Treatment) 4 (302)

<u>Steer No.</u>	<u>Initial</u>	<u>Final</u>
37	460	1000
44	465	900
206	440	930
224	425	960
252	405	925
233 2/	465	961 1/
258	370	975
259	380	920
260	315	810

Lot No. (Treatment) 5 (301)

<u>Steer No.</u>	<u>Initial</u>	<u>Final</u>
8	470	1040
11	525	1055
30	440	1015
220	425	985
229	420	930
234	435	1020
246	330	910
249	420	995
251	335	850
257	385	880

1/ Estimated weights at time of death and data not included in results of Trial.

2/ Data not included in analysis of covariance.

APPENDIX TABLE III. SUMMARY OF WEIGHTS, AVERAGE DAILY GAINS, DAILY FEED CONSUMPTION, AND FEED CONVERSION OF CATTLE ON PELLETTED CONCENTRATE RATIONS. (Trial I -- December 15, 1962 to August 12, 1963 -- 240 days).

Lot No.	1	2	3	4	5
MSC Formula No.	300	298	303	302	301
<u>Comparisons:</u>					
Barley ground	X		X	X	X
Barley steam rolled		X			
Wheat millrun	X	X	X		
CSM and SBOM	X	X			
Safflower meal			X	X	X
Safflower hulls			X		
No. Steers <u>1/</u>	10	9	10	8	10
<u>Avg. Wt. (lbs.)</u>					
Final	957	986	967	928	968
Initial	409	412	418	408	419
Gain	548	574	549	520	549
Daily gain	2.29	2.39	2.29	2.17	2.29
<u>Avg. Daily Ration (lbs.)</u>					
Pellets	15.25	15.33	15.25	14.25	16.01
Grass hay	3.09	3.11	2.95	2.87	3.11
Salt	0.01	0.02	0.03	0.03	0.02
Total	18.35	18.46	18.23	17.15	19.14
<u>Avg. Feed/cwt. Gain (lbs.)</u>					
Pellets	667	641	667	658	699
Grass hay	135	130	129	132	135
Salt	0.5	1.0	1.4	1.3	0.8
Total	803	772	797	792	836

1/ One steer died of bloat in Lot 2 on June 27, 1963; one steer removed from Lot 4 on April 4, 1963, because of chronic bloat; one steer died in Lot 4 on July 13, 1963, from chronic bloat. Data on these steers not used in calculating results.

APPENDIX TABLE IV. CARCASS DATA OF STEERS FED PELLETTED CONCENTRATE RATIONS AS A FATTENING RATION. (Trial I -- 240 days).

Treatment	300	298	303	302	301
Lot No.	1	2	3	4	5
Carcass yields <u>1</u> /	58.4	58.9	57.8	58.6	58.9
Rib eye (sq. in./cwt.)	1.87	1.83	1.83	1.93	1.93
Fat thickness 12 rib. in.	0.9	1.0	0.8	0.8	0.9
Marbling score <u>2</u> /	3.8	3.0	4.7	3.7	3.6
Avg. carcass grade <u>3</u> /	4.5	3.6	5.0	4.5	4.4

1/ Based on cold carcass weight (warm carcass minus 3 percent pencil shrink).

2/ Based on: Small minus 1; Small 2; Small plus 3; Moderate minus 4; Moderate 5; Moderate plus 6; High minus 7; High 8; High plus 9.

3/ Based on: High choice 6; Average choice 5; Low choice 4; High good 3; Average good 2; Low good 1.

APPENDIX TABLE V. SUMMARY OF EXPENSES AND RETURNS OF STEERS FATTENED ON
PELLETED ALL-CONCENTRATE RATIONS. (Trial I -- 240 days).

Lot No.	1	2	3	4	5
<u>Average/Steer</u>					
Feed cost/cwt. gain					
(\$ <u>1</u> /	21.71	19.27	17.98	18.51	19.62
Gain (cwt.)	5.48	5.74	5.49	5.20	5.49
<u>Financial Return</u>					
(Dollars)/Steer:					
Feed cost	118.97	110.61	98.71	96.25	107.71
Initial cost <u>2</u> /	139.55	140.57	142.62	139.21	142.96
Total Investment	258.52	251.18	241.33	235.46	250.67
Gross Return <u>3</u> /	232.22	238.88	233.90	226.24	236.19
Net Return	-26.30	-12.30	-7.43	-9.22	-14.48

1/ Based on: Ration 300-\$3.05; Ration 298-\$2.80; Ration 303-\$2.50;
Ration 302-\$2.61; Ration 301-\$2.61; Hay-\$1.00; Salt-\$1.62/
cwt.

2/ Initial cost \$34.12/cwt. delivered to Bozeman, Montana.

3/ Based on: \$42.00/cwt. choice carcass and \$40.50/cwt. good carcass.

APPENDIX TABLE VI. ANALYSIS OF VARIANCE AND COVARIANCE OF INITIAL AND FINAL WEIGHTS OF STEERS FED PELLETTED CONCENTRATE RATIONS. (Trial I -- 240 days).

Source of Variation	D.F.	Sum Squares due to:		
		Initial	Initial x Final	Final
Treatments	4	1384	1993	15327
Error	42	118999	122454	236394
Total	46	120383	124447	251721
Treatments + Error	46	120383	124447	251721
<u>Deviations about Regression</u>				
		<u>Sum Squares</u>	<u>D.F.</u>	<u>Mean Square</u> <u>F Value</u>
Error Adjusted		110385	41	2692
Treatments		139686	45	
Treatments Adjusted		29301	4	7325 2.72*

*No significant difference in weight gains of steers fed pelleted concentrate rations.

APPENDIX TABLE VII. SUMMARY OF WEIGHT GAINS AND FEED CONSUMPTION AND FEED CONVERSION OF HEREFORD STEER CALVES FED TWO LEVELS OF CONCENTRATES WITH LONG OR WAFERED ALFALFA HAY. (Trial II -- November 26, 1963 to February 17, 1964 -- 84 days).

Lot No.	1	2	3	4
<u>Treatment:</u>				
Hay	Wafered	Long	Long	Wafered
Concentrates-average				
lbs./day 1/	2.00	2.00	4.00	4.00
Salt and mineral supp.	ad lib.	ad lib.	ad lib.	ad lib.
No. Steers	9 2/	9 2/	9 2/	8 2/
<u>Average Wts. (lbs.)</u>				
Final	567	527	551	571
Initial	432	417	417	423
Gain	135	110	134	148
Average daily gain 3/	1.61 ^a	1.31	1.59 ^b	1.77 ^{abc}
<u>Average Daily Ration (lbs.)</u>				
Barley	1.42	1.42	2.66	2.66
Beet pulp	0.58	0.58	1.34	1.34
Supplement 4/	0.12	0.12	0.12	0.12
Hay	11.42	11.47	9.41	9.41
Mineral	0.01	0.01	0.01	0.01
Salt	0.04	0.04	0.04	0.04
Total	13.59	13.64	13.57	13.58
<u>Avg. Feed/Cwt. Gain (lbs.)</u>				
Barley	88.40	108.69	167.05	151.43
Beet pulp	36.13	44.04	84.15	75.38
Supplement	7.20	8.84	7.26	6.64
Hay	710.70	875.61	589.75	531.74
Mineral	0.33	0.40	0.33	0.34
Salt	2.63	2.73	2.24	2.52
Total	845.39	1040.31	850.78	767.95

- 1/ Steamed rolled barley and beet pulp.
- 2/ One calf in each of Lots 1, 2 and 3, and two calves in Lot 4 died of bloat. Data on these calves were not used in calculating results of Trial II.
- 3/ (a) Gains of steers fed wafered hay were greater than steers fed long hay ($P < 0.05$).
 (b) Gains of steers fed 4.00 lbs/day concentrates were greater than steers fed 2.00 lbs/day ($P < 0.05$).
 (c) Steers in Lot 4 gained more than steers in Lot 2 ($P < 0.01$).
- 4/ Supplement used during last 20 days of trial as a carrier for antibiotics.

APPENDIX TABLE VIII. SUMMARY OF EXPENSES AND ESTIMATED RETURNS OF STEER CALVES WINTERED ON LONG OR WAFERED ALFALFA HAY AND TWO LEVELS OF CONCENTRATES. (Trial II -- 84 days).

Lot No.	1	2	3	4
<u>Treatment:</u>				
Hay	Wafered	Long	Long	Wafered
Concentrates-avg.				
lbs./day	2.00	2.00	4.00	4.00
Salt and mineral	ad lib.	ad lib.	ad lib.	ad lib.
Feed cost/cwt. gain (\$) <u>1/</u>	10.33	12.70	11.84	10.69
Gain (cwt.)	1.35	1.10	1.34	1.48
<u>Financial Return</u> <u>(Dollars)/Steer:</u>				
Feed cost	13.95	13.97	15.87	15.82
Initial cost <u>1/</u>	120.96	116.76	116.76	118.44
Total investment	134.91	130.73	132.63	134.26
Estimated Gross Return <u>3/</u>	147.42	137.02	143.26	148.46
Estimated Net Return	12.51	6.29	10.63	14.00

1/ Based on: Supplement-\$6.32; Beet Pulp-\$1.98; Barley-\$2.25; Hay-\$1.00; Salt-\$1.62, and Mineral Supplement-\$3.92/cwt.

2/ Initial cost \$28.00 delivered to Bozeman, Montana.

3/ Based on estimated selling price of \$26.00/cwt.

APPENDIX TABLE IX. INITIAL AND FINAL WEIGHTS OF STEER CALVES WINTERED ON WAFERED OR LONG ALFALFA HAY AND TWO LEVELS OF CONCENTRATES.

Lot No. (Treatment) 1 (Wafer + 2 lbs.)			Lot No. (Treatment) 4 (Wafer + 4 lbs.)		
Steer No.	Initial	Final	Steer No.	Initial	Final
306	415	500	304	455	610
331	475	635	330	435	560
351	395	545	336	395	555
359	490	670	339	375	530
369	420	560	382	480	630
392	490	615	407	420	570
403	400	500	414	410	555
404	415	580	415	410	560
411	390	500			
Total	3890	5105	Total	3380	4570

Lot No. (Treatment) 2 (Long + 2 lbs.)			Lot No. (Treatment) 3 (Long + 4 lbs.)		
Steer No.	Initial	Final	Steer No.	Initial	Final
300	395	485	329	420	550
316	390	460	345	460	615
353	425	515	366	400	540
356	365	515	368	430	585
362	485	610	376	390	500
370	420	535	383	430	570
389	480	650	402	435	560
401	380	485	406	390	530
408	410	485	412	400	510
Total	3750	4740	Total	3755	4960

APPENDIX TABLE X. ANALYSIS OF VARIANCE AND COVARIANCE OF HEREFORD STEER CALVES WINTERED ON LONG OR WAFERED ALFALFA HAY AND TWO LEVELS OF CONCENTRATES. (Trial II -- 84 days).

Source of Variation	D.F.	Sum Squares due to:		
		Initial	Initial x Final	Final
Hay	1	1001	2828	7989
Concentrates	1	196	-565	1628
Hay x concentrates	1	1402	2723	10724
Error	31	38665	48395	72238
Total	34	41264	53382	92579
Hay + Error	32	39666	51223	80227
Concentrates + Error	32	38861	47830	73866
Hay x Concentrates + Error	32	40067	51118	82962

Deviations about Regression

	<u>Sum Squares</u>	<u>D.F.</u>	<u>Mean Square</u>	<u>F Value</u>
Error Adjusted	11664	30	389	
Hay Adjusted	2416	1	2416	6.20*
Concentrate Adjusted	3333	1	3333	8.57*
Hay x Concentrate Adjusted	6081	1	6081	15.64**

*Significant P less than 0.05.

**Significant P less than 0.01.

APPENDIX TABLE XI. INITIAL AND FINAL WEIGHTS OF STEERS FATTENED ON PELLETED CONCENTRATE RATIONS FOLLOWING A WINTERING RATION OF WAFERED OR LONG ALFALFA HAY AND TWO LEVELS OF CONCENTRATES. (Trial III -- Fattening Period -- 157 days, and Trial II -- Wintering Period -- 84 days). 1/

Lot No. (Treatment) 1 (Wafer + 2 lbs.)			Lot No. (Treatment) 4 (Wafer + 4 lbs.)		
Steer No.	Initial	Final	Steer No.	Initial	Final
306	500	825	304	610	945
351	545	1005	330	570	935
359	665	1130	336	560	950
369	555	960	339	525	900
392	620	1030	407	565	935
403	515	895	414	560	935
404	580	965	415	575	955
411	500	820			
Total	4480	7630	Total	3965	6555

Lot No. (Treatment) 2 (Long + 2 lbs.)			Lot No. (Treatment) 3 (Long + 4 lbs.)		
Steer No.	Initial	Final	Steer No.	Initial	Final
300	490	860	329	545	910
316	465	790	345	615	995
353	520	910	366	555	945
356	505	905	368	590	950
362	615	1015	376	500	870
370	540	935	383	560	950
389	665	1100	402	555	910
			406	525	845
			412	510	840
Total	3800	6515	Total	4955	8215

1/ Gain data from results of Trial III and relotted according to wintering period for statistical analysis to test effects of wintering ration on gains in fattening trial.

APPENDIX TABLE XII. ANALYSIS OF VARIANCE AND COVARIANCE OF STEERS FATTENED ON PELLETTED CONCENTRATE RATIONS FOLLOWING A WINTERING RATION OF WAFERED OR LONG ALFALFA HAY AND TWO LEVELS OF CONCENTRATES.

Source of Variation	D.F.	Sum Squares due to:		
		Initial	Initial x Final	Final
Hay	1	1936	3065	4855
Concentrates	1	234	-848	3058
Hay x concentrates	1	2323	2106	7242
Error	27	67781	97641	155587
Total	30	72274	101964	170742
Hay + Error	28	69717	100706	160442
Concentrates + Error	28	68015	96793	158645
Hay x Concentrates + Error	28	70104	99747	162829

Deviations about Regression

	<u>Sum Squares</u>	<u>D.F.</u>	<u>Mean Square</u>	<u>F Value</u>
Error Adjusted	14932	26	574	
Hay Adjusted	40	1	40	0.07
Concentrate Adjusted	5966	1	5966	10.39**
Hay x Concentrate Adjusted	5973	1	5973	10.41**

**Significant P less than 0.01.

APPENDIX TABLE XIII. INITIAL AND FINAL WEIGHTS OF STEERS FATTENED ON PELLETED CONCENTRATE RATIONS. (Trial III -- February 22, 1964 to July 28, 1964 -- 157 days).

Lot No. (Treatment) 1 (375)

<u>Steer No.</u>	<u>Initial</u>	<u>Final</u>
304	610	945
339	525	900
382 <u>1/</u>	630	945
336	560	950
333	510	910
361	540	900
403	515	895
414	560	935
415	575	955

Lot No. (Treatment) 2 (376)

<u>Steer No.</u>	<u>Initial</u>	<u>Final</u>
334	500	815
345	615	995
350	520	830
366	555	945
368	590	950
380	520	895
383	560	950
401 <u>1/</u>	525	845
412	510	840

Lot No. (Treatment) 3 (377)

<u>Steer No.</u>	<u>Initial</u>	<u>Final</u>
300 <u>1/</u>	490	860
387	530	965
347	545	960
349	540	825
353	520	910
370	540	935
389	665	1100
402	555	910
410	540	940

Lot No. (Treatment) 4 (378)

<u>Steer No.</u>	<u>Initial</u>	<u>Final</u>
306	500	825
334	465	880
351	545	1005
360	530	900
369	555	960
392	620	1030
404	580	965
407	565	935
411	500	820

Lot No. (Treatment) 5 (379)

<u>Steer No.</u>	<u>Initial</u>	<u>Final</u>
330	570	935
316	465	790
329	545	910
356	505	905
359	665	1130
376	500	870
362	615	1015
405	505	860
413	525	955

1/ Steers not on trial for 157 days, and were replacements for calves not terminating trial for various reasons. Data on replacement calves not used in statistical analysis of covariance.

APPENDIX TABLE XIV. SUMMARY OF INITIAL AND FINAL WEIGHTS, AVERAGE DAILY GAIN, FEED CONVERSION AND DAILY FEED CONSUMPTION OF CATTLE FED PELLETED CONCENTRATE RATIONS. (Trial III -- 157 days).

Lot No.	1	2	3	4	5
Ration	375	376	377	378	379
<u>Comparisons:</u>					
CSM + SBOM	X	X			
Safflower (23)			X	X	
Safflower (43)					X
Oats (% ration)	17.5	35.0	17.5	35.0	17.5
No. Steers/Lot	9	9	9	9	9
<u>Avg. Wts. (lbs.)</u>					
Final	926	896	934	924	930
Initial	558	544	547	540	544
Gain	368	352	387	384	386
Avg. daily gain	2.34	2.24	2.46	2.45	2.46
<u>Avg. Feed/cwt. Gain (lbs.)</u>					
Pellets	668	657	688	657	622
Hay	214	223	208	240	199
Salt	1	1	1	1	1
Total	883	881	897	898	822
<u>Daily Ration (lbs.)</u>					
Pellets	15.79	14.78	17.06	16.09	15.30
Hay	5.06	5.01	5.15	5.88	4.90
Salt	0.02	0.02	0.03	0.02	0.02
Total	20.87	19.81	22.24	21.99	20.22

APPENDIX TABLE XV. CARCASS DATA OF STEERS FED PELLETTED CONCENTRATE RATIONS IN A FATTENING RATION. (Trial III -- 157 days).

Lot No.	1	2	3	4	5
Carcass yield <u>1/</u>	59.4	58.0	58.3	59.1	59.3
Rib eye 12th rib.					
sq. in./cwt. <u>2/</u>	1.85	1.85	1.83	1.84	1.85
Fat thickness 12th rib. in.	0.8	0.6	0.8	0.9	0.7

1/ Based on warm carcass weight minus 3 percent pencil shrink.

2/ Loin eye area at 12th rib/cwt. of shrunk carcass.

APPENDIX TABLE XVI. SUMMARY OF FINANCIAL DATA OF CATTLE FED PELLETTED CONCENTRATE RATIONS. (Trial III -- 157 days).

Lot No.	1	2	3	4	5
Treatment	375	376	377	378	379
Feed cost/cwt. gain (\$) <u>1/</u>	20.93	20.85	20.68	20.23	19.42
Gain (cwt.)	3.68	3.52	3.87	3.84	3.86
Financial Return (Dollars)/Steer:					
Feed cost	77.02	73.39	80.03	77.68	74.96
Initial cost <u>2/</u>	145.08	141.44	142.22	140.40	141.44
Total Investment	222.10	214.83	222.25	218.08	216.40
Gross Return	203.10	190.62	201.32	201.59	204.20
Net Return	-19.00	-24.21	-20.93	-16.49	-12.20

1/ Based on: Ration 375-\$2.81; Ration 376-\$2.83; Ration 377-\$2.70; Ration 378-\$2.71; Ration 379-\$2.80; Hay-\$1.00; Salt-\$1.62/cwt.

2/ Initial cost \$26.00/cwt. delivered to Bozeman, Montana.

3/ Based on carcass grade basis: \$37.00/cwt. choice carcass and \$36.00/cwt. good carcass.

APPENDIX TABLE XVII. ANALYSIS OF VARIANCE AND COVARIANCE OF STEERS FED PELLETED CONCENTRATE RATIONS. (Trial III -- 157 days).

Source of Variation	D.F.	Sum Squares due to:		
		Initial	Initial x Final	Final
Treatments	4	1004	1073	6918
Error	37	84170	112610	198756
Total	41	85174	113683	205674
Treatments + Error	41	85174	113683	205674

Deviations about Regression

	<u>Sum Squares</u>	<u>D.F.</u>	<u>Mean Square</u>	<u>F Value</u>
Error	48096	36	1336	
Treatments Adjusted	5844	4	1461	1.09

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Evaluation of pelleted or
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