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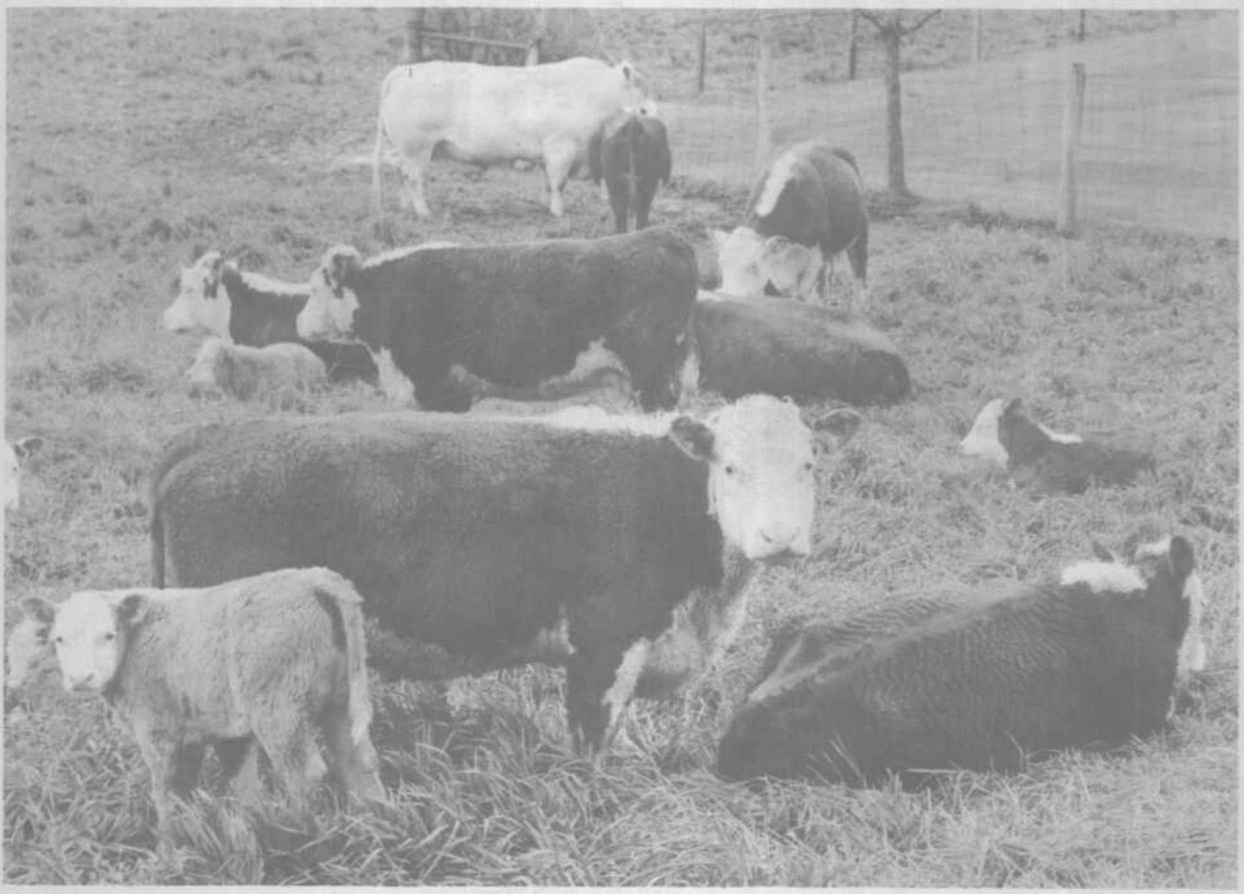
BEEF CATTLE RESEARCH 1966



OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER
Wooster, Ohio

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NET ENERGY VALUE OF CORN SILAGE AND GROUND EAR CORN WHEN FED SEPARATELY OR IN COMBINATION TO FATTENING STEERS AND HEIFERS

E. W. Klosterman, H. W. Ockerman, and V. R. Cahill
Department of Animal Science

Net energy is the most accurate measure of the energy value of a feed for productive purposes. Net energy is determined by subtracting the energy lost through the feces, urine, combustible gases, and heat increment from the total gross energy of a feed. Thus, by definition, net energy is the amount of energy in a feed which is available for the production of growth, fattening, milk, etc.

Net energy values usually have been determined with a respiration calorimeter or a respiration chamber where all heat losses are measured directly or estimated indirectly from gaseous exchange. These methods have a number of definite limitations. They are costly in equipment and labor. Only a limited number of animals can be used and these can be used only for a short time and under very unnatural conditions.

A method of estimating net energy values of feeds for beef cattle with a comparative slaughter technique has been developed by Lofgreen (2) at the California Agricultural Experiment Station. This method is based upon the amount of energy stored by a group of animals fed a specified ration for a period of time. A representative sample of animals is slaughtered at the beginning of the experiment and their chemical composition is determined by the specific gravity of the carcass. At the end of the experiment, the same information is obtained on cattle fed the ration being tested. From the composition of the carcass at the start and the end of the experiment, the amount of energy stored from a measured amount of feed can be determined.

This method, with minor modifications, was used in this experiment to estimate the net energy value of corn silage, ground ear corn, and a combination of the two when they were fed to growing-fattening steers and heifers.

Steers and heifers can both be fattened satisfactorily on a variety of rations. There are some basic differences, however. Most notable of these is the more rapid fattening of the heifer. When fed the same ration, heifers will fatten at an earlier age and lighter weight than steers. One objective of this experiment was to determine if the net energy value of rations varying in energy content might differ when fed to steers or heifers.

This experiment was conducted at the Northwestern Branch of the Ohio Agricultural Research and Development Center at Hoytville. Two concrete stave silos were filled with well-eared, well-matured, whole plant corn to which 10 lb. of urea, 10 lb. of ground limestone, and 2 lb. of dicalcium phosphate were added per ton at the time of ensiling. This corn silage yielded 17 tons per acre. An average of 12 dry matter determinations made at regular intervals during the experiment showed that the silage contained 38.3 percent dry matter. Similar corn at this location yielded 100 bushels of grain per acre. The other feeds included were: a mixture of ground ear corn, 85%, and urea, 15%; dehydrated alfalfa, pelleted (17% protein, 100,000 units vitamin A); trace mineralized salt; and a mixture of 4 parts steamed bonemeal and 1 part salt.

Choice quality Hereford steers and heifers were purchased from a ranch in northern Texas and shipped to Ohio in early October. The supply of silage available was not adequate to feed the cattle from this date until the desired final weight. So all cattle were fed the same ration of hay and grain until the experiment was started on December 21, 1965. At the start of the experiment, the steers were implanted in the ear with 30 mg. of stilbestrol and the heifers with 15 mg.

Initial and final live weights were shrunk weights taken after the cattle were held off feed and water overnight. Steers and heifers were randomized within weight groups in three lots each. Three steers and three heifers were selected at random within weight groups and slaughtered to determine initial body composition.

The objective was to feed the heifers to an average weight of 850 lb. and the steers to 1000 lb. This was attained in all instances except for steers full fed silage because the supply of silage was inadequate to carry them to that weight.

When a lot of cattle reached the desired weight, a shrunk weight was taken and the animals were paired according to weight. One animal of each pair was randomly selected for slaughter in the Meat Laboratory and the other was sold at the local auction.

The empty body weight of the cattle slaughtered was calculated by subtracting the weight of paunch fill from the live weight at slaughter. This empty weight was expressed as a percentage of the shrunk weight taken prior to shipment. This percentage was then used to estimate the empty weight of the animals fed in the experiment.

Detailed carcass data were obtained which included separating the round, loin end, rib, and chuck into edible portion, bone, and fat trim. These results were used to estimate the percentages of each in the total carcass. The 9-11 rib section minus the bone was ground and sampled for the determination of moisture, fat, protein, and ash. The percent body water of the empty body weight was estimated by the following formula, which was derived from equations presented by Kraybill et al (1):

$$\text{Percent body water} = 72.3 - (0.6227)(\%\ \text{fat 9-11 rib})$$

This percentage was used to estimate total energy content of the empty body according to the procedure outlined by Lofgreen (2). Differences in energy content of the initial and final samples of cattle were used to determine energy storage and the net energy value of the rations fed. The constant used to estimate the amount of energy expended for maintenance was $75W_{kg}^{0.75}$.

TABLE 1.--Performance of Steers and Heifers Full Fed Corn Silage, Ground Corn or a Combination of the Two

	Silage		Silage + Corn		Corn	
	Steers	Heifers	Steers	Heifers	Steers	Heifers
Number	14	14	14	14	13	14
Av. wt., Dec. 21, lb.	575	554	570	557	575	560
Av. final wt.	943	841	993	851	998	836
Av. daily gain	1.94	1.87	2.52	2.22	2.25	2.19
Days fed	189	154	168	133	189	126
Av. daily ration, lb.						
Corn silage	35.6	34.3	10.0	10.0	-	-
Ground ear corn	-	-	13.5	11.7	14.9	14.3
Corn-urea mix	-	-	1.2	1.2	1.5	1.5
Dehydrated alfalfa	1.0	1.0	1.0	1.0	1.0	1.0
Av.ration dry matter	14.5	14.0	16.9	15.4	14.4	14.0
Ration D.M. per cwt.	1.91	2.01	2.16	2.19	1.83	2.01
Feed per cwt. gain, lb.						
Corn silage	1832	1841	396	449	-	-
Ground ear corn	-	-	536	526	663	653
Corn-urea mix	-	-	48	54	67	68
Dehydrated alfalfa	51	54	40	45	45	46
Ration dry matter	748	754	670	692	643	637
Pounds of beef per acre	1687	1642	1009	995	922	932
Dressing percentage	59.2	59.3	61.4	60.8	62.1	60.3
Marbling score[1]	4.7	5.7	5.7	5.6	5.6	5.7
Final grade[2]	17.7	19.3	19.3	18.9	19.2	18.9
Fat thickness, inches	0.28	0.50	0.42	0.57	0.50	0.37
Area rib eye, sq. in.	10.0	8.9	10.0	9.5	9.6	9.1
Edible portion, %	72.6	67.8	70.1	67.0	71.1	69.0
Bone, %	18.1	16.1	15.8	14.5	15.7	15.3
Fat trim, %	9.3	16.1	14.1	18.5	13.2	15.7
Tenderness score	22.4	22.5	16.0	25.1	18.9	19.5

[1] Slight, 4; small, 5 and modest, 6.

[2] Low, average and high good; 16, 17 and 18 and low, average and high choice; 19, 20 and 21, respectively.

Results shown in Table 1 are in agreement with previous comparisons of steers and heifers. Steers ate slightly more feed per head daily and gained faster than heifers. However, on a per unit of weight basis, the heifers consumed more ration dry matter daily and were fatter at a final weight of about 850 lb. than steers were at 1000 lb. There was very little difference between the sexes in amount of dry matter required to produce 100 lb. of live weight gain or in the pounds of gain produced per acre. In calculating gain per acre of total cropland fed, the yield of dehydrated alfalfa was estimated at 4 tons per acre.

Average daily gains and feed intake were greatest when a combination of corn silage and ground ear corn was fed. Feed requirements per unit of gain increased with increased amounts of silage. However, the amount of beef produced per acre also increased with a full feed of corn silage. An accurate comparison of the merits of corn silage and ear corn should include costs of harvesting, storing, and feeding. These costs would be markedly influenced by the size of the entire cattle feeding enterprise.

When fed to a similar final weight, there did not appear to be large and consistent differences in carcass grade or composition of heifers fed the three rations. Those full fed silage tended to yield a lower percentage of carcass, however. Unfortunately, the supply of silage was not sufficient to carry the steers full fed silage to the same weight as those fed the other two rations. When slaughtered at a final weight 50 lb. lighter, steers full fed silage were not as highly finished and did not grade as high as those fed rations with ground ear corn.

Chemical composition of the gains (Table 2) show that increases in empty body weight of heifers were considerably higher in fat and lower in protein than those made by steers. This resulted in a greater storage of calories by heifers and, on the average, a higher net energy value of rations when fed to heifers (Table 3). There appeared to be an interaction among rations and sexes in this regard. The net energy value of the corn silage ration was 15 percent higher when fed to heifers. There was little difference in net energy value of the ear corn ration when fed to either steers or heifers.

The results of this experiment will be checked by a second experiment with similar rations and similar cattle. However, the increased intake of ration dry matter per 100 lb. of liveweight by heifers was consistent with all three rations. This greater intake over and above maintenance needs would leave more energy for body storage in heifers than in steers. Although the primary purpose of feeding cattle in dry lot is to fatten them, the higher fat content of the heifer carcass is not considered particularly desirable. As shown in Table 2, steers stored more protein per head daily than heifers.

In view of the well known differences between steers and heifers in ease of fattening, perhaps more emphasis should be given to differences in rations which should be fed to each. It appears that heifers are especially well adapted to the use of a corn silage ration.

TABLE 2.--Composition of Gains of Steers and Heifers fed Corn Silage, Ground Ear Corn or a Combination of the Two

	Silage		Silage + Corn		Corn	
	Steers	Heifers	Steers	Heifers	Steers	Heifers
Av. empty wt. gain, lb.	319	253	392	273	390	253
Fat gain, lb.	108	141	171	163	197	131
Protein gain, lb.	52	28	57	26	50	30
Composition of gain:						
Fat, %	33.9	55.7	43.6	59.7	50.5	51.8
Protein, %	16.3	11.1	14.5	9.5	12.8	11.9
Water and ash, %	49.8	33.2	41.9	30.8	36.7	36.3
Energy gain, Mcal/day	3.147	4.368	5.198	5.719	5.117	5.048
Protein gain, lb./day	0.28	0.18	0.34	0.20	0.26	0.24

TABLE 3.--Net Energy Value of Corn Silage and Ground Ear Corn Rations When fed to Fattening Steers and Heifers

	Silage		Silage + Corn		Corn	
	Steers	Heifers	Steers	Heifers	Steers	Heifers
Av. of initial and final empty wts., lb.	678	625	710	637	713	630
Av. metabolic wt., $W_{kg}^{0.75}$	73.6	69.2	76.2	70.2	76.4	69.6
Energy required for maintenance, Mcal/day(M)[1]	5.520	5.190	5.715	5.265	5.730	5.220
Energy gain, Mcal/day (P)	3.147	4.368	5.198	5.719	5.117	5.048
Total net energy, Mcal/day (M+P)	8.667	9.558	10.913	10.984	10.847	10.268
Dry matter intake, lb./day	14.5	14.0	16.9	15.4	14.4	14.0
Net energy, Mcal/100 lb.DM	59.8	68.3	64.6	71.3	75.3	73.3
Net energy of ration as fed, Mcal/100 lb.	23.7	27.2	42.4	45.9	62.5	60.9
Net energy value for heifers as percent of steer value		115		108		97

[1] Energy requirement for maintenance estimated to be $75W_{kg}^{0.75}$

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1. Kraybill, H. F., H. L. Bitter, and O. G. Hankins. 1952. Determination of fat and water content from measurement of body specific gravity. J. Applied Physiol. 4:575.

2. Lofgreen, G. P. 1964. A comparative slaughter technique for determining net energy values with beef cattle. Proc. Third Symposium on Energy Metabolism, Troon, Scotland.

DIGESTIBILITY OF DOUBLE EAR CORN SILAGE SUPPLEMENTED WITH LIMESTONE, UREA, AND DIAMMONIUM PHOSPHATE

R. R. Johnson, K. E. McClure, and E. W. Klosterman
Department of Animal Science

In feeding trials, "complete silage" or silage made with a double quantity of ears plus limestone, urea, and dicalcium phosphate was found to be satisfactory as the sole ration for growing-fattening beef cattle. Such a system offers the opportunity of handling just one feed and also is a convenient means to provide the nitrogen supplement for beef cattle.

The earlier feeding studies involved only limited investigation of digestibility of these silages. In the present study, sheep were used to determine the digestibility of the following rations:

1. Double ear corn silage made with 0.5% limestone and 1.0% diammonium phosphate (DAP).

2. Double ear corn silage made with 0.5% limestone, 0.5% urea, and 0.1% defluorinated phosphate.

3. Double ear corn silage made with 1.0% DAP.

4. Double ear corn silage made with 1.0% limestone and 0.1% defluorinated phosphate and fed with sufficient urea to be equivalent to 0.5%.

The composition and digestibility of these rations are presented in Table 1. Because of the late date of harvest and the double ears, the dry matter is fairly high, 46%. The silages made with nitrogen supplements contained 11% or more crude protein, which is in the range recommended for growing-fattening beef cattle. Although the digestibility of the dry matter in Ration 2 appears to be lower than the other rations, observations of the individual data suggest there is little difference between the rations. The digestibility of the protein in Ration 4 appears to be somewhat higher than in the other rations. These data have not been analyzed statistically so it is not possible to say these differences are significant at this time. All systems tested appeared to be suitable for supplementing double ear-corn silage.

TABLE 1.--Digestibility of Double Ear-Corn Silage Supplemented with Limestone, Urea and DAP

	Ration Number			
	1	2	3	4[a]
Additives to double ear-corn silage[b], %				
Limestone	0.5	0.5	-	1.0
Urea	-	0.5	-	-
DAP	1.0	-	1.0	-
Defluorinated phosphate	-	0.1	-	0.1
Composition, %				
Dry matter	46.3	45.6	46.1	45.5
Protein	10.9	11.3	11.9	9.1
Apparent digestibility, %				
Dry matter	72.1	68.3	70.3	71.1
Protein	59.6	56.2	60.3	66.9

[a] Fed with 0.5% urea added at feeding time.

[b] Silage made on October 12, 1965.

FEEDING VALUE OF DIAMMONIUM PHOSPHATE AND UREA WHEN FED IN DRY SUPPLEMENT OR MIXED WITH SILAGE AND CORN IN A COMPLETE SILAGE

E. W. Klosterman, K. E. McClure, and V. R. Cahill
Department of Animal Science

Research results published previously by the Ohio Agricultural Research and Development Center have shown that the addition of urea to chopped whole plant corn at the time of ensiling is a practical method of increasing the crude protein content of corn silage. It was also found that an addition of 1 percent pulverized limestone or a mixture of equal parts of limestone and urea had a favorable effect upon fermentation in the silo and that silage so treated had a slightly higher feeding value. More recent results have shown that a complete feed for fattening cattle can be made by doubling the normal amount of ears in whole plant corn silage and by adding 0.5% urea, 0.5% limestone, and 0.1% of a high phosphorus mineral to the chopped corn at the time of ensiling.

Additions of either 0.5% or 1% pulverized limestone have been shown to increase the feeding value of corn silage. However, when added at the higher level and calculated on a dry matter basis, these limestone additions have been fully 3% of the dry ration. Although favorable results were obtained, these additions had a marked effect upon the calcium to phosphorus ratio of the ration fed. This raised the question whether or not the feeding results might be improved further by maintaining a more nearly normal ratio of these two major minerals.

Diammonium phosphate (DAP) contains approximately 20% phosphorus and enough nitrogen to supply approximately 106% crude protein equivalent. Thus it can be used as a high phosphorus supplement as well as a source of non-protein nitrogen. The DAP used in this experiment was supplied through the courtesy of International Minerals and Chemical Corporation and contained 0.17 percent fluorine. Fertilizer grades of DAP may contain too much fluorine to be used as a livestock feed.

Three different silages were made for this experiment. Regular, whole plant corn silage was made with the addition of 1.0% pulverized limestone and 0.1% defluorinated rock phosphate. Two double ear silages were made by picking and grinding the ears from an area of corn with a New Idea picker-grinder and then adding whole plant, chopped corn from an equal area of corn. One silo was filled with this combination plus 0.5% urea, 0.5% pulverized limestone, and 0.1% defluorinated rock phosphate. The third silo was filled with the double ear corn and additions of 1.0% DAP and 0.5% pulverized limestone.

Although they varied slightly in dry matter content, all silages were made from well-matured corn. Dry matter and crude protein content of samples of each silage taken at intervals during the feeding experiment are shown below. At this stage of development, the ear is considerably drier than the entire plant and thus the double ear silages were somewhat higher in dry matter than the regular silages without added ears.

Silage	Dry Matter, percent	Protein, percent, D. M. basis
Regular whole plant		
+ lime and phosphate	38.2	8.5
Double ear		
+ urea, lime, and phosphate	48.9	10.5
+ DAP and lime	43.5	10.2

Eighty head of choice quality, Hereford feeder steers were used in this experiment. They were purchased from a single ranch in northern Texas and shipped to Wooster in early October, 1965. The supplies of silage available were not adequate to finish the cattle to slaughter weight. So all steers were fed 8 lb. per head daily of a mixture of 85% ground ear corn and 15% soybean meal with a full feed of hay until January 11, 1966. They were then divided at random within weight groups into 8 lots of 10 steers each. All lots were fed in an open sided shed without access to outdoor lots. Each of the following rations was fed to two groups:

1. 6.2 lb. per head daily of a mixture of 94.5% ground ear corn and 5.5% DAP with the limestone-treated, whole plant silage full fed.

2. 6.2 lb. per head daily of a mixture of 97.0% ground ear corn and 3.0% urea with the limestone-treated, whole plant silage full fed.

3. A full feed of double ear, DAP, limestone-treated silage.

4. A full feed of the double ear, urea-limestone-phosphate-treated silage.

In addition, all lots were allowed free access to trace mineralized salt and to a mixture of 4 parts defluorinated rock phosphate and 1 part salt. All steers were implanted with 15 mg. stilbesterol per head at the start of the experiment.

The experimental rations were fed for 133 days until May 24, when the supplies of double ear silages were exhausted. The steers fed these rations were then fed the whole plant silage with ground ear corn and either DAP or urea, the same as had been in their silage, until June 27. The steers were slaughtered through a local packing plant and individual carcass data were obtained. Results of this experiment are presented in Table 1.

Steers fed the whole plant silage with added dry corn gained definitely faster than those fed the double ear silages. This difference was undoubtedly influenced by the amount of grain in the ration. On a dry matter basis, steers fed the regular silage with added grain received considerably more grain than those fed the complete silages and consumed more dry matter per head daily. However, steers fed the

TABLE 1.--Feeding Value of Diammonium Phosphate and Urea When Fed in a Dry Supplement or Mixed with Silage and Corn in a Complete Silage

	Limestone treated silage plus dry corn and supplement		Complete silage including corn and supplement	
	DAP	Urea	DAP	Urea
Number of steers	20	20	20	20
Average weight, January 11, lb.	637	637	637	637
Average weight, May 24, lb.	985	977	933	941
Average daily gain, 133 days, lb.	2.62	2.56	2.23	2.28
Average daily ration, lb.				
Silage	28.0	26.5	29.0	28.9
Corn - supplement mix[1]	6.2	6.2	-	-
Ration dry matter	16.2	15.7	12.6	14.1
Feed per 100 lb. gain, lb.				
Silage	1068	1034	1311	1268
Corn - supplement mix[1]	238	240	-	-
Ration dry matter	621	611	570	620
Slaughter weight, June 27, lb.[2]	994	996	947	952
Dressing percentage	59.6	60.1	60.8	61.2
Marbling score	6.2	6.1	6.1	6.2
Final grade[4]	19.2	19.2	19.2	19.5
Kidney, %	2.8	3.0	2.8	2.8
Fat thickness, inches	.47	.42	.43	.39
Area rib eye, sq. in.	11.0	11.2	11.0	11.7
Trimmed retail cuts, percent	49.8	50.1	50.3	50.9

1

	Mixture	
	DAP	Urea
Ground ear corn,%	94.5	97.0
DAP,%	5.5	-
Urea,%	-	3.0

2 Shrunk weight minus 3 percent.

3 Modest - 6, moderate - 7.

4 Low, average and high choice - 19, 20, 21, respectively.

complete silages were fully as efficient as they produced 100 lb. of gain with slightly less dry matter than those fed the dry grain. The DAP-treated silage appeared to be the most efficient of the complete silages.

Although the complete silages were not fed for the last month, the slaughter weights on June 27 were relatively the same as on May 24. Steers fed the complete silages had not gained quite as fast, were 45 lb. lighter at time of slaughter, and had slightly less fat over the rib eye than those fed regular silage plus dry corn. However, their carcass grades and yields were as high as those which had gained at a faster rate and they had a slightly higher percentage of the carcass in closely trimmed retail cuts from the round, loin, rib, and chuck as estimated from the U.S.D.A. equation.

Nearly identical results were obtained with urea and diammonium phosphate as sources of nitrogen. This was true whether they were mixed with the silage or with dry ground ear corn fed with silage. Slightly less corn dry matter was required to produce a unit of gain with the DAP-treated silage. This difference may or may not have been due to the additional phosphorus supplied by the DAP and may not have been a real difference. Further studies are planned to compare DAP and urea mixed with silage or in a dry supplement.

DIGESTIBILITY OF REGULAR CORN SILAGE SUPPLEMENTED WITH CORN AND UREA, DIAMMONIUM PHOSPHATE, OR SOYBEAN MEAL

R. R. Johnson, K. E. McClure, and E. W. Klosterman
Department of Animal Science

In previous studies it was found that ensiling corn plant material with limestone or limestone plus urea had no effect on the digestibility of the silage dry matter. However, the digestibility of a typical beef cattle fattening ration of silage and ground ear corn plus nitrogen supplement has not been compared with the digestibility of silage made with limestone plus urea and fed with ground ear corn.

In this study, regular whole plant corn silage was made in a steel tower silo with 1.0% limestone and 0.1% defluorinated phosphate. This was fed to lambs along with ground ear corn in the proportion of 1.5 lb. silage dry matter to 1.0 lb. ear corn dry matter. In addition, the ground ear corn was supplemented with either urea, diammonium phosphate, or soybean meal on an equal nitrogen basis. The fourth ration consisted of regular corn silage made from the same corn plant material but ensiled in plastic bags with 0.5% limestone, 1.0% urea, and 0.1% defluorinated phosphate. This was fed with ground ear corn in the same proportions as the other rations.

The results of this digestion trial are given in Table 1. There were no differences in dry matter digestibility between the feeding systems. Although the protein digestibility for the feeding system in which the silage was made with urea appeared to be higher, the differences were not statistically significant. Thus, the time of addition of nitrogen supplement (before ensiling or at feeding) or the type of nitrogen supplement (urea, DAP, or soybean meal) did not affect the digestibility of silage-corn rations tested in this study.

TABLE 1.--Digestibility of Regular Corn Silage Supplemented with Ground Ear Corn and Nitrogen Sources

	Silage made with Limestone and CDP[a] Fed with			Silage made with Limestone, Urea and CDP Fed with
	Ground Ear Corn+ Urea	Ground Ear Corn + DAP	Ground Ear Corn + SBOM	Ground Ear Corn
Percent D.M. in Silage	36.6	36.6	36.6	37.4
Percent Protein in Silage	9.2	9.2	9.2	15.5
Apparent Digestibility				
Dry Matter, %	69.9	71.5	71.4	70.5
Protein, %	68.1	66.9	65.4	69.3

[a] Defluorinated phosphate.

MATURITY OF CORN USED FOR WHOLE PLANT CORN SILAGE

R. R. Johnson, K. E. McClure, and E. W. Klosterman
Department of Animal Science

In Beef Cattle Research--1965 (Res. Summary 7, January 1966), a report was given on a 1964 study of the digestibility of corn silages made at seven stages of maturity. It appeared that the maximum yield of ears was not achieved until the glaze stage of maturity and dry matter digestibility reached a maximum around the dent stage. However, high dry matter digestibility was maintained even in the silage made after a killing frost (55% dry matter). Because of increasing interest in higher dry matter (later maturity) corn silages, this study was repeated in 1965.

As in the previous study, corn plant material was harvested from a single field plot of corn at eight stages of maturity. The first seven stages corresponded to those used in the previous year's work (Table 1) and the eighth stage consisted of a harvest taken on December 7. Half of each harvest was ensiled without treatment in large plastic bags and the other half was treated with urea and limestone prior to ensiling.

In the 1964 study, 0.5% each of urea and limestone were added to the silages. However, with the widely varying dry matter content, it was realized that this type of treatment led to widely varying final concentrations of urea and limestone. Thus, the dry matter content of the 1965 silages was estimated and the urea and limestone were added in proportions equivalent to the addition of 0.5% each to a 30% dry matter silage. This amounted to additions as shown below:

	Amount added, wet basis	
Harvest date	Urea, %	Limestone, %
8-18	0.33	0.33
8-25	0.33	0.33
9-3	0.38	0.38
9-10	0.46	0.46
9-22	0.56	0.56
10-5	0.76	0.76
10-14	0.82	0.82
12-7	0.90	0.90

The silages were fed to sheep in digestion trials to determine apparent digestibility coefficients. Dry urea was added to the untreated silages at feeding time to be approximately equal to the urea content of the treated silages. This was done to insure that any effects on dry matter digestibility would not be due to differences in nitrogen intake.

The content and digestibility of dry matter and protein in the silages for both years are compared in Table 1. Harvest dates during

TABLE 1.--Composition and Apparent Digestibility of Dry Matter and Protein in Silages Made at Different Maturities in 1964 and 1965

Harvest Date	Stage	Treat-ment	% D.M.		% Protein[c,d]		Apparent Digestibility Dry Matter		Apparent Digestibility Protein[d]	
			1964	1965	1964	1965	1964	1965	1964	1965
8-17,18	Blister	-	20.9	21.3	12.0	11.4	65.3	71.0	74.7	76.7
		UL[a]	20.2	20.7	14.1	15.1	66.1	66.6	72.4	74.1
8-25	Early milk	-	19.9	22.1	12.1	11.9	66.7	67.9	75.9	75.6
		UL	21.5	23.7	15.4	15.4	66.5	69.3	75.0	75.8
9-2,3	Milk-dough	-	21.9	24.9	10.8	12.3	69.5	72.6	77.6	77.4
		UL	23.9	27.0	14.8	15.9	69.4	70.4	76.0	75.7
9-9,10	Dough-dent	-	27.5	27.9	10.4	11.4	71.9	71.9	76.2	75.6
		UL	27.2	28.6	12.8	14.6	71.8	70.7	74.1	74.0
9-21,22	Glaze	-	33.5	33.9	9.4	11.0	67.8	-	69.1	-
		UL	34.6	33.5	-	14.5	70.4	69.5	-	70.6
10-5,6	Flint	-	45.4	38.4	9.0	11.0	71.0	68.6	66.9	67.2
		UL	47.2	39.3	11.5	14.7	68.1	67.1	66.4	65.3
10-14,15	Post-frost[e]	-	49.2[b]	46.7	8.7	10.5	69.8	68.2	64.8	66.3
		UL	50.8[b]	46.8	10.6	14.4	71.8	66.0	65.2	68.4
12-7		-		71.7		10.9		68.6		59.4
		UL		71.0		11.3		67.4		51.1

[a] UL = urea + limestone added at ensiling time.

[b] Approximately 5% water added at ensiling time.

[c] Dry matter basis.

[d] The protein value for untreated silages is for the silage as it came from the bags. During the trial, urea was added to this silage to equalize that present in the treated silages so the digestion coefficient includes the added urea.

[e] Frost dates for 1964 and 1965 were 10-6 and 10-13 respectively.

1965 were chosen to be comparable to 1964 and were judged to be approximately at the same stage of ear development. The dry matter contents suggest that the plants were maturing (drying) slightly faster in 1965 during the early part of the test period but were not as dry at the flint stage as in 1964. Many of the crude protein contents of the silages harvested in 1965 were higher at all later stages of maturity than those harvested in 1964. The reasons for this are not apparent except that the different plot locations for the two years may have involved differences in fertility level.

In 1964, dry matter digestibility appeared to increase with maturity up to the dough stage, after which it remained constant. In 1965, a similar but less marked trend was observed but digestibility appeared to be slightly decreased at the flint and post-frost stages. In both years, protein digestibility remained high (around 75%) through the dough-dent stage, after which it declined. There were no marked differences in digestibility of dry matter or protein due to the time of addition of urea (ensiling time or feeding time).

No decrease in digestibility of dry matter could be observed between the post-frost harvest and that taken on December 7. A sharp decrease in protein digestibility occurred during this period, however. Although with this technique the December 7 silage appeared to be satisfactorily preserved with little or no mold, its odor was not characteristic of conventional high quality silage. Palatability was not impaired by this, however.

The following conclusions can be made from this 2-year study:

1. Maximum yield in terms of dry matter per acre is achieved somewhere between the dent and glaze stage of ear development.

2. Dry matter digestibility of corn silage reaches a maximum at about its dent stage and may decrease slightly in later stages of maturity.

3. Protein content and digestibility decrease after the dough-dent stage of maturity.

4. Corn plant material can be ensiled satisfactorily after a killing frost and result in a high quality, palatable silage.

5. Silage made on December 7 (71% dry matter) had an odor not characteristic of normal corn silage but appeared to preserve well in plastic bags and was palatable for sheep.

ULTRASONIC EVALUATION OF CATTLE

L. A. Swiger, E. W. Klosterman, and V. R. Cahill[1]
Department of Animal Science

Ohio and many other research stations in the United States and other countries are attempting to use ultrasonics to evaluate live meat animals for lean and fat composition. The advantages of such evaluation are obvious as a research technique and more importantly as a tool for selection of seedstock by breeders. Lean-fat body composition is an important trait of beef cattle. Genetic improvement for this trait could be made more rapidly if an accurate method of live animal evaluation could be used, rather than total reliance on carcass data of relatives.

Ultrasonic evaluation measures the depth of fat or muscle by the length of time taken for reflection of sound waves by different tissues in an animal's body. A transducer which both emits and receives the reflections is placed against the animal. The reflection signals or "blips" appear on the face of an oscilloscope tube. Distances between blips represent depth between various tissues of the body.

The purpose of the research reported here was to evaluate the accuracy of the ultrasonic technique under conditions similar to those expected in field use. The results reported below for beef cattle are discouraging but they are preliminary and further work will be done. Good success has been obtained in predicting lean cut percentage on live pigs.

The first study involved ultrasonic and carcass measures of 59 head of beef cattle. In this study, rib eye area and fat over the rib were measured at about the 13th rib with the ultrasonic equipment. A polaroid picture of the rib scan was taken and evaluated. Carcass fat and rib eye area at the 13th rib were recorded, along with percent edible product. This is the percent of the carcass in boned, trimmed chuck, round, rib, and sirloin. Percent edible product is an excellent measure of carcass composition as it relates to the consumer.

The correlation between ultrasonic and carcass rib eye area was 0.49. However, the correlation of live weight with rib eye area was 0.45 as the cattle varied considerably in weight. The accuracy of measuring rib eye among cattle of the same weight is a proper test of the technique. This was done statistically with the data and the result was 0.35. This value is not high enough to be a sound basis for live evaluation.

The correlation between ultrasonic and carcass fat measures on a weight constant basis was 0.63. Obviously fat thickness over the rib can be measured with better accuracy than rib eye area.

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[1]W. W. Wharton, D. L. Davis, and R. E. Smith of the Ohio Cooperative Extension Service and G. R. Wilson, Ohio Agricultural Research and Development Center and The Ohio State University, were primarily responsible for the ultrasonic measures.

An equation was derived for predicting percent edible product from live weight, ultrasonic fat, and ultrasonic rib eye. Predicted percent edible product with this equation had a correlation with carcass percent edible product of 0.49. Omitting ultrasonic rib eye from the prediction equation lowered the correlation only to 0.47. A prediction equation using carcass fat, carcass rib eye, and live weight gave a correlation of 0.68. This shows the accuracy that could be obtained with accurate live animal measures of fat and rib eye. Omitting carcass rib eye from the latter equation lowered the correlation only to 0.64.

Thus, with an expectation of reasonable accuracy in measuring fat and evidence that weight and fat together could predict composition nearly as well as including rib eye, the next effort was to concentrate on measuring fat thickness.

The second study was made on 40 head of beef cattle. The objective was to evaluate the accuracy of measuring fat thickness with the ultrasonic equipment and to investigate certain repeatabilities with the equipment.

In this study, the transducer was held directly against the animal by one worker while another read fat depth directly from the oscilloscope. Two operators evaluated all cattle on two successive days. Fat depth was measured at the 13th rib and at the hooks. One operator had the same transducer holder throughout. The other operator used two holders, with each holder working the same 20 head each day. The cattle were slaughtered and fat depth at the 13th rib was recorded.

The most startling result was the effect of the transducer holder on correlations between ultrasonic fat measures and carcass fat (Table 1) and on repeatabilities between ultrasonic measures. Repeatabilities between the same measures on different days ranged from -.01 to 0.44 for holder C but were 0.82 for the rib measure and 0.70 for the hooks measure for holder D. Repeatabilities between rib and hooks measurements and between operators were not as high as desirable but this is probably a result of the poor performance of holder C.

As shown in Table 1, correlations between ultrasonic fat and carcass fat were very low when C held the transducer. Reasonably high correlations were obtained with holder D. Thus, it appears that reasonably good results can be achieved in measuring fat ultrasonically on beef cattle. However, this unexpected effect of the transducer holder requires further clarification before prediction equations for edible product can be formulated and recommended for field use.

TABLE 1.--Correlations between Ultrasonic Fat as Measured by Two Operators on Successive Days and Carcass Fat of 40 Hereford Steers

Day	Oscilloscope Operator	Transducer Holder	Lots	Correlation with Carcass Fat	
				Rib	Hooks
1	A	C	1,2	0.14	0.10
2	A	C	1,2	-.10	0.03
1	A	C	7,8	0.09	0.34
2	A	C	7,8	-.22	0.01
1	B	C	1,2	-.03	0.16
2	B	C	1,2	0.24	-.16
1	B	D	7,8	0.84	0.78
2	B	D	7,8	0.73	0.46

MAINTENANCE REQUIREMENTS OF HEREFORD AND CHAROLAIS COWS FED TWO LEVELS OF PROTEIN[1]

E. W. Klosterman, L. G. Sanford, and C. F. Parker
Department of Animal Science

When the feeds needed to maintain beef breeding herds are included, approximately 75-80 percent of the total energy fed to beef cattle is used to meet maintenance needs. These maintenance needs are commonly expressed as a constant, although there is not complete agreement as to what this constant should be. Such a constant is contrary to normal expected biological variation. Because of the tremendous overhead cost of beef production, the lack of information on possible variation among individual beef animals, and the numerous environmental factors which may affect maintenance requirements, further research in this area seemed essential.

Body weight to the 0.75 power is the relationship between body weight and energy needs for maintenance used by the National Research Council Committee on Animal Nutrition and the one most generally accepted. However, several exponents of body weight, varying from 0.6 to 1.0, have been suggested. Interactions among body weight, body condition, and energy needs for maintenance have not been investigated.

Efficient use of energy by an animal is dependent upon its being fed a ration balanced in other nutrients. This is particularly true of protein, the nutrient which is likely to be low in wintering rations for beef cows. The primary objective of the experiments reported here was to determine if the energy needs of mature beef cows are influenced by the amount of protein in the ration.

The cows used in these experiments were mature, open, non-lactating Hereford and Charolais cows. Many had been used in a Hereford-Charolais crossbreeding experiment underway at this Research Center. Cows used in the first experiment were from the Research Center and The Ohio State University. These were cows which had not calved in the spring and some carried an extreme amount of finish. Those fed in the second experiment had each nursed a calf and were placed on experiment about 1 month after the calves had been weaned in the fall. Many were in a thin condition.

The cows were housed in a shed with access to an outside lot. They were bedded with sawdust and were fed once daily in individual feeding stalls. Each cow was fed according to her theoretical maintenance requirement, which was estimated from the formula:

$$\text{lb. TDN} = .036\ W_{\text{lb.}}^{0.75}$$

This amount of feed was held constant for the entire feeding experiment. The cows were weighed weekly prior to feeding and following

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[1]Data in this paper were taken from a thesis submitted by Lorin G. Sanford in partial fulfillment of the requirements for the M. S. degree at The Ohio State University.

an overnight stand without water. To remove some of the error of a single weight, regression lines were fitted to the weekly weights of each cow and her initial and final weights were estimated from this line. The cows were measured for height at the hooks and an ultrasonic measurement of thickness of fat over the last rib 4 inches from the midline was recorded.

The cows were assigned at random within breed to one of the two rations listed in Table 1. Trace mineralized salt and a mineral mixture of steamed bonemeal and salt were provided free choice.

Statistical analyses of the average daily gains are presented in Table 3. There were no significant differences due to experiment, ration, or breed. The overall average daily gain and constants for these main effects are listed in Table 4. There was considerable variation among cows, with a standard deviation of 0.25 lb. for weight change per day.

These results indicate that the low level of protein as fed, 6.9% total crude protein, was adequate to maintain the weight of mature, non-pregnant, non-lactating beef cows. Feeding a higher level of protein apparently did not increase the efficiency of energy utilization as cows fed a 12.0% protein ration and equal amounts of energy did not gain significantly more.

There was a highly significant correlation of 0.52 between fat thickness over the last rib and average daily gain. There was also a tendency for cows with a high weight-height ratio to gain more or lose less weight than those with a low weight-height ratio, as indicated by a partial regression coefficient of .098 lb. per day. This increased weight for unit of height is largely a measure of condition.

Cows which had a high degree of finish tended to maintain or gain weight, while those which were in thin condition lost weight. The amount of feed fed to each cow was determined from her weight at the time the experiments were started. Since the fatter cows were heavier, they received more feed per head daily.

Results of these experiments suggest that an accurate description of the amount of feed needed for the maintenance of mature beef cows should include a measure of condition in addition to body weight. Between large and small types of cattle and within certain crossbred herds, weight alone is not an accurate indication of the condition of the cows.

TABLE 1.--Composition of Rations Fed

	Low Protein	High Protein
	%	%
Ground corn cobs	65	65
17% Dehydrated alfalfa	10	10
Ground corn	25	10
Soybean oil meal	-	15
Crude protein	6.9	12.0
TDN	55.2	55.2

Experiment I was conducted for a 16 week period from August 3 to November 23, 1965 and Experiment II for 15 weeks from December 7, 1965 to March 22, 1966. Averages by experiments and breeds are presented in Table 2.

TABLE 2.--Averages by Experiments and Breeds

	Experiment I		Experiment II	
	Hereford	Charolais	Hereford	Charolais
Number	12	2	13	11
Initial weight, lb.	1105	1382	983	1154
Final weight, lb.	1134	1430	950	1041
A.D.G., lb.	0.17	0.31	-0.12	-0.34
Height, cm.	120	142	121	132
Fat thickness, cm.	3.16	2.38	1.75	0.87

TABLE 3.--Analysis of Variance, Weight Change per Day

	D.F.	Mean Square	Ratio
Total	38		
Reduction	6	.4073	
Error	32	.0630	
Experiment	1	.0784	1.24
Ration	1	.1705	2.71
Breed	1	.0902	1.43
Regression on weight change			
Fat thickness	1	.0468	0.74
Weight-height ratio	1	.2416	3.83

TABLE 4.--Least-Squares Constants for the Effects of Experiment, Ration and Breed on Weight Change per Day

Treatment	Pounds
Least squares mean	-.066
Experiment	
I	.071
II	-.071
Ration	
Low protein	-.070
High protein	.070
Breed	
Charolais	-.059
Hereford	.059
Linear regression on weight change	
Fat thickness	.006
Weight-height ratio	.098

TOTAL FEED EFFICIENCY OF BEEF PRODUCTION UNDER TWO SYSTEMS OF MANAGEMENT

Earle W. Klosterman
Department of Animal Science

The feed required to maintain a beef cow for 1 year must be charged against her calf. At birth, very little actual beef has been produced. The heavier the calf becomes, the smaller this requirement is in proportion to the total feed needed to produce a given weight of slaughter beef. On the other hand, young animals utilize their feed more efficiently than older animals. Thus, two opposing forces are operating in determining what age or weight of cattle can be produced most efficiently. Very limited research data have been available to answer this question when the overall feed requirement of the beef herd is considered.

One objective of a Hereford and Charolais crossbreeding experiment at the Ohio Agricultural Research and Development Center has been to compare the two breeds and their crosses under two systems of management. Half of the calves produced were creep-fed, fattened in dry lot immediately following weaning, and slaughtered at 12 to 14 months of age. The other half were not creep-fed, were wintered to gain 1 to 1.25 lb. per head daily, grazed for an average of 76 days, fattened in dry lot, and slaughtered at 18 to 20 months of age. Detailed, comparative results of the Hereford and Charolais breeds and their crosses will be published elsewhere.

It was not possible to maintain the breeds of cows as separate herds or to feed the wintering calves by breed groups. So it will not be possible to compare the overall total feed efficiency of the two breeds. However, the breeds and sexes were fed separately during the fattening phase. This report compares the two systems of management without regard to breed as the breeds and crosses were equally represented in both systems.

Two replicates or herds of cattle were included in this experiment. Each herd consisted initially of 25 Hereford and 25 Charolais heifers. Approximately the same numbers were maintained for the three calf crops included in this study. Both herds were started with yearling heifers and feed records were initiated the fall after the heifers had been bred on pasture. Records were obtained of all harvested feeds fed to the cows as well as to the calves. These weights of feed were converted to pounds of total digestible nutrients (TDN). From the number of days on pasture, average weight, and average gain during the pasture season, the amount of TDN obtained from pasture was estimated from theoretical requirements for maintenance and gain. The formula used to make these pasture estimates was published by Garrett, Meyer, and Lofgreen (1) and is:

$$TDN = 0.036W_{lb.}^{0.75} (1 + 0.57 \text{ gain})$$

The TDN obtained from pasture by the suckling calf was credited directly to the pasture. A significant but unmeasurable part of this was obtained indirectly from the pasture through the milk produced by the calf's dam. During some dry seasons, the pastures were supplemented with hay which was credited to the pasture rather than charged to the winter feed.

The results for each replicate and their averages are presented in Tables 1-3. These results represent a total of approximately 300 cow-calf years.

The amount of TDN required by the cow tended to increase each year in both replicates. This was due to the increased weight associated with the increased age of the heifers. The amount obtained from pasture the third year by the first replicate of cows was lower as the cows lost an average of 34 lb. during the pasture season. During the other five pasture seasons, the cows gained from 39 to 219 lb. per head, with an average gain of 127 lb.

At weaning time, the nutrients required to carry a cow for a year are a high percentage of the total. As indicated in Table 3, these were 72 and 75% for the early and late slaughtered groups, respectively. The remaining nutrients were obtained by the calf from pasture and milk from the dam. The TDN supplied through the creep was about 10% of the total to weaning and increased the weaning weight an average of 70 lb. per head. This reduced the total nutrients required per hundredweight of calf from 870 to 801 lb. These data emphasize the importance of the economical feeding of the cow and the value of creep feeding if the calves are to be sold at weaning time.

When slaughtered, the creep fed group required 714 pounds of TDN per 100 lb. liveweight and the non-creep group 782 lb. or approximately 10% more. The non-creep group averaged 105 lb. heavier at slaughter and the percentage of nutrients required by the cow was reduced from 48% to 40% of the total.

The results of these experiments indicate that the creep fed calves which were fattened immediately following weaning produced their weight with the least TDN per unit of weight. However, these cattle obtained 40% of their energy from concentrates (fattening ration plus creep feed) while those slaughtered at an older age required only 23% from the fattening ration. The most beef with the least amount of grain would have been produced by the creep fed calves if they had been slaughtered at weaning time. The creep fed calves more nearly approached a slaughter condition at weaning time than the non-creep calves, which had received no grain prior to weaning. The most profitable system of management would thus be determined by the kind and cost of feed available.

Reference

1. Garrett, W. N., J. H. Meyer, and G. P. Lofgreen. 1959. The comparative energy requirements of sheep and cattle for maintenance and gain. J. Animal Sci. 18:528.

TABLE 1.--Total Digestible Nutrients Required to Produce a Unit of Beef under Two Systems of Management

Replicate I

	Creep fed, fattened			Wintered, grazed, fattened		
	1959 to 1961	1960 to 1962	1961 to 1963	1959 to 1961	1960 to 1962	1961 to 1963
	.......pounds.......			.......pounds.......		
TDN required per head to:						
Winter cow	927	1609	2156	927	1609	2156
Pasture cow	1798	2002	1107	1798	2002	1107
Pasture calf	772	895	893	1024	1143	961
Creep feed	516	295	430	-	-	-
Winter calf	-	-	-	1441	1252	1524
Pasture yearling	-	-	-	634	755	543
Fatten in dry lot	2065	2251	2540	1886	1695	2242
TDN required to weaning	4013	4801	4586	3749	4754	4224
Weaning weight	566	537	613	475	520	489
TDN per cwt.	709	894	748	789	914	864
Percent required by cow	68	75	71	73	76	77
Total TDN	6078	7052	7126	7710	8456	8533
Final weight	913	909	996	1015	1051	1124
TDN per cwt.	666	776	716	760	805	759
Percent required by cow	45	51	46	35	43	38

TABLE 2.--Total Digestible Nutrients Required to Produce a Unit of Beef under Two Systems of Management

Replicate II

	Creep fed, fattened			Wintered, grazed, fattened		
	1962 to 1964	1963 to 1965	1964 to 1966	1962 to 1964	1963 to 1965	1964 to 1966
	.......pounds.......			.......pounds.......		
TDN required per head to:						
Winter cow	1393	1407	1587	1393	1407	1587
Pasture cow	1482	1790	2233	1482	1790	2233
Pasture calf	734	707	886	955	1112	1172
Creep feed	459	593	397	-	-	-
Winter calf	-	-	-	1393	1298	1383
Pasture yearling	-	-	-	832	433	677
Fatten in dry lot	2446	2270	2052	1754	2364	1662
TDN required to weaning	4068	4497	5103	3830	4309	4992
Weaning weight	548	556	565	463	491	529
TDN per cwt.	742	809	903	827	878	944
Percent required by cow	71	71	75	75	74	77
Total TDN	6514	6767	7155	7809	8404	8714
Final weight	1023	941	929	1038	1025	1090
TDN per cwt.	637	719	770	752	820	799
Percent required by cow	44	47	53	37	38	44

TABLE 3.--Total Digestible Nutrients Required to Produce a Unit of Beef under Two Systems of Management

Average Results

	Creep fed, fattened			Wintered, grazed, fattened		
	Rep.1	Rep.2	Average	Rep.1	Rep.2	Average
TDN required per head to:						
Winter cow	1564	1462	1513	1564	1462	1513
Pasture cow	1636	1835	1736	1636	1835	1736
Pasture calf	853	776	814	1043	1080	1062
Creep feed	414	483	448	-	-	-
Winter calf	-	-	-	1406	1358	1382
Pasture yearling	-	-	-	644	647	646
Fatten in dry lot	2285	2256	2270	1941	1927	1934
TDN required to weaning	4467	4556	4511	4243	4377	4311
Weaning weight	572	556	564	495	494	494
TDN per cwt.	784	818	801	856	883	870
Percent required by cow	71	72	72	75	75	75
Total TDN	6752	6812	6781	8234	8309	8273
Final weight	939	964	952	1063	1051	1057
TDN per cwt.	719	709	714	775	790	782
Percent required by cow	47	48	48	39	40	40

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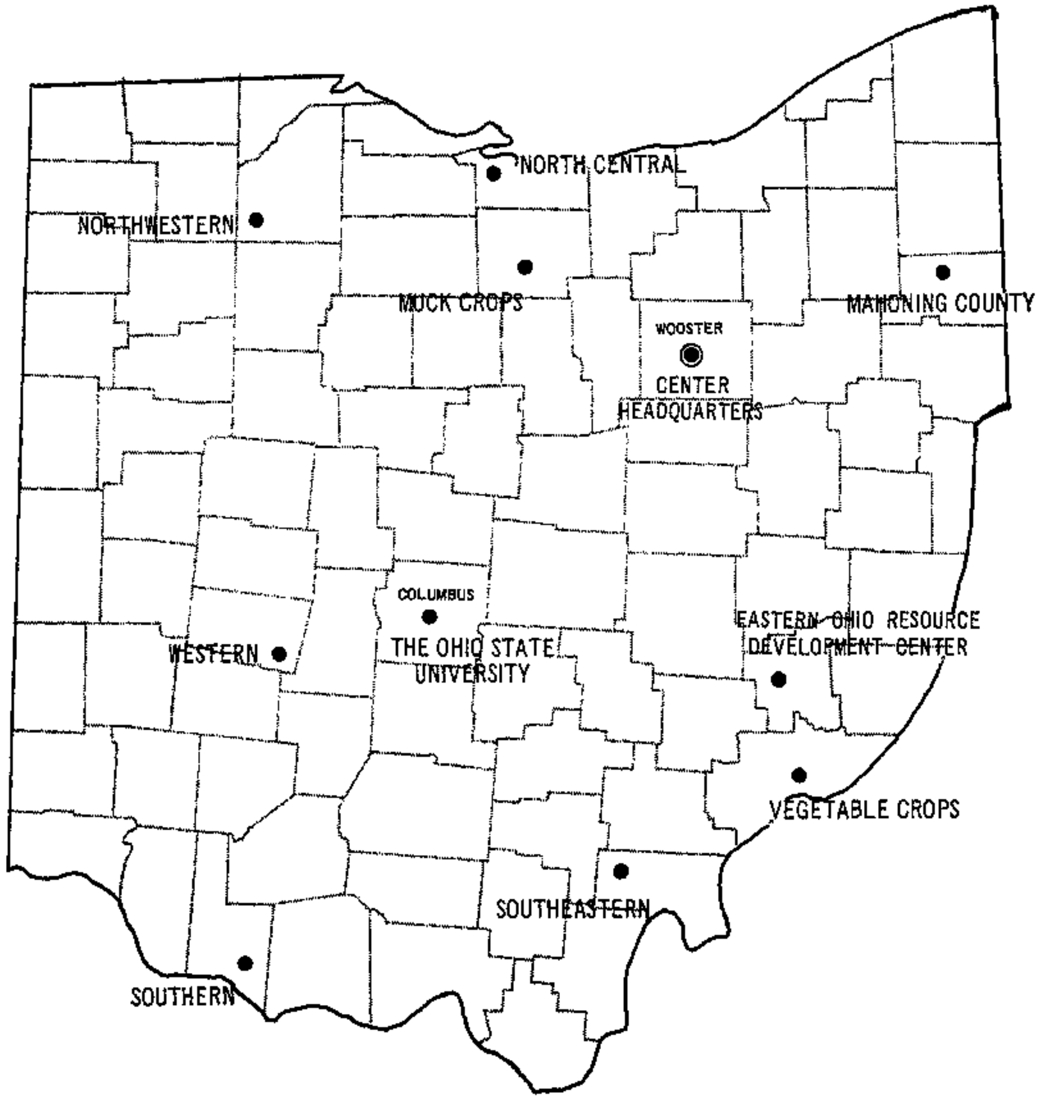

Ohio's major soil types and climatic conditions are represented at the Research Center's 11 locations. Thus, Center scientists can make field tests under conditions similar to those encountered by Ohio farmers.

Research is conducted by 14 departments on more than 5900 acres at Center headquarters in Wooster, nine branches, and The Ohio State University.

Center Headquarters, Wooster, Wayne County: 2017 acres

Eastern Ohio Resource Development Center, Caldwell, Noble County: 2039 acres

Mahoning County Experiment Farm, Canfield: 275 acres

Muck Crops Branch, Willard, Huron County: 15 acres

North Central Branch, Vickery, Erie County: 335 acres

Northwestern Branch, Hoytville, Wood County: 247 acres

Southeastern Branch, Carpenter, Meigs County: 330 acres

Southern Branch, Ripley, Brown County: 275 acres

Vegetable Crops Branch, Marietta, Washington County: 20 acres

Western Branch, South Charleston, Clark County: 428 acres