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U.S. Metric	**Metric U.S.**
Length:	
1 inch = 2.54 centimeters	1 millimeter = 0.03937 inch
1 foot = 30.48 centimeters	1 centimeter = 0.3937 inch
= 0.3048 meters	1 meter = 39.37 inches
1 yard = 0.9144 meters	= 3.281 feet
1 mile = 1609.34 meters	= 1.094 yards
= 1.609 kilometers	1 kilometer = 0.6214 mile
Area:	
1 square inch = 6.452 sq. centimeters	1 sq. centimeter = 0.155 sq. inch
1 sq. foot = 0.0929 sq. meter	1 sq. meter = 1.196 sq. yards
1 sq. yard = 0.8361 sq. meter	= 10.764 sq. feet
1 acre = 0.4047 hectare	1 hectare = 2.471 acres
1 sq. mile = 259.0 hectares	1 sq. kilometer = 0.386 sq. mile
	= 247.1 acres
Volume:	
1 cubic inch = 16.387 cu. centimeter	1 cu. centimeter = 0.061 cu. inch
1 cu. foot = 0.0283 cu. meter	1 cu. meter = 35.315 cu. feet
1 cu. yard = 0.7646 cu. meter	= 1.308 cu. yards
1 fluid ounce = 29.573 milliliters	1 milliliter = 0.0338 ounce
1 pint = 0.4732 liter	1 liter = 33.81 ounces
1 quart = 0.9463 liter	= 2.1134 pints
1 gallon = 3.7853 liters	= 1.057 quarts
	= 0.2642 gallon
	1 kiloliter = 264.18 gallons
Weight:	
1 ounce = 28.50 grams	1 gram = 0.03527 ounce
1 pound = 453.592 grams	1 kilogram = 35.274 ounces
= 0.4536 kilogram	= 2.205 pounds
1 ton = 907.2 kilograms	1 metric ton = 2204.6 pounds (1,000 kg)

Cow-Calf Stocker

Selection For Increased Weaning Weight and Yearling Weight In Hereford Cattle

T. A. Stanforth and R. R. Frahm

Story in Brief

Performance data on 827 calves raised from 1964 through 1973 were analyzed to determine the amount of selection applied and the responses obtained in two 50-cow lines of Hereford cattle. One line was selected for increased weaning weight (WWL) and the other for increased yearling weight (YWL). The average performance has been similar in the two lines over the duration of the study which suggests that similar genetic responses are occurring in both lines.

The amount of selection practiced was determined by cumulative selection differentials. Male selection accounted for 80 and 83 percent of the total selection applied for weaning weight in the WWL and yearling weight in the YWL, respectively. Thus, these results reinforce the importance of selecting genetically superior herd sires. In both lines there were substantial positive cumulative selection differentials for birth-weight, postweaning ADG and weaning and yearling conformation scores as well as for weaning weight in YWL and yearling weight in WWL. These correlated selection differentials were slightly larger in the YWL.

On an independent set of cows, calves sired by selected bulls after seven years of selection were 5.6, 5.9 and 6.9 percent heavier at birth, weaning and yearling, respectively, and grew 11 percent faster postweaning than calves sired by foundation sires. Overall these results indicate that selection based on either weaning weight, yearling weight or both should result in appreciable improvement in overall performance.

Introduction

The entire beef industry is currently undergoing a critical self-evaluation with each segment taking a close look at how net profit can

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In cooperation with USDA, Agricultural Research Service, Southern Region.

be increased in spite of rising production costs. Purebred and commercial cattlemen are vitally concerned about the selection of genetically improved breeding stock since selection is the primary force available for improving the average genetic merit of breeds and herds.

Because growth rate has a major impact on net returns, breeders are currently placing considerable emphasis on growth performance when selecting breeding animals. Relatively little research information is available, however, to quantitatively evaluate the effectiveness of selection for increased growth rate for improving total beef cattle performance. Evaluation of how rapidly improvement can be attained in traits directly selected for and the magnitude and direction of changes in related traits will be of considerable value in determining which traits to emphasize in beef cattle selection programs. This study was conducted to determine the amount of selection applied and the responses obtained in two lines of Hereford cattle selected for weaning weight and yearling weight, respectively.

Experimental Procedure

The primary data used in this study were the performance records of 827 registered Hereford calves raised from 1964 through 1973 as part of the beef cattle selection project being conducted by the Oklahoma Agricultural Experiment Station. Foundation animals used to initiate the project were purchased from several herds in the midwest and southwest and were assembled at the Fort Reno Livestock Research Station, El Reno, Oklahoma starting in 1960. Selection lines were formed by random allocation of foundation females to lines in 1963 to formally initiate the project. Weaning weight, standardized to 205 days and adjusted for age of dam, was the selection criterion in one line (WWL). Yearling weight, standardized to 365 days for bulls and 425 days for heifers, was the selection criterion in the other line (YWL). Foundation females were the progeny of 16 different sires and 10 bulls were used from 1963 through 1966 as foundation sires. Subsequent to 1966 the lines were closed and all replacement breeding stock selected from within each line based on the respective selection criteria of the two lines.

Each line was maintained at 50 cows and 4 sires. Each year two bulls were selected from each line on their respective criteria and were used two years and discarded. The 13 top heifers were selected from each line each year and bred as yearlings. The top 10 pregnant heifers, based on a fall pregnancy examination, were then retained in each line. The lines were maintained at 50 cows by culling 10 cows yearly on the following criteria: (1) serious unsoundness, (2) not pregnant based on fall pregnancy examination and (3) oldest age.

The selection lines were managed as a single herd except during the breeding season and when circumstances such as pasture size and forage availability dictated otherwise. The cow herd grazed native range during the spring and summer and native range and wheat pasture, when available, during the winter. Prairie hay, alfalfa and cottonseed cake were supplemented during the winter as dictated by forage availability, weather conditions and condition of the cattle.

Bulls were placed with the cows in single sire breeding pastures on May 1 each year. Calves were born in the spring starting about February 1. All calves were tatooed, ear tagged and weighed within 24 hours of birth. Calves ran with their dams without creep feed and were weaned in the fall when the average age of all calves was 205 days. Conformation and condition scores were determined at weaning and yearling ages by a panel of at least three qualified persons.

After weaning, bull calves were given a two week warm up period prior to being placed on a feedlot performance test. Feedlot performance tests were 160 days in duration through 1971 and 140 days in subsequent years. Heifers were placed on wheat pasture after weaning and supplemented with prairie hay, alfalfa, grain and cottonseed meal so as to gain from 0.75 to 1.00 pounds per day from weaning to 425 days.

Complete performance records were collected on each calf through a year of age for bulls and through 425 days of age for heifers. The records used in this study were birth weight, weaning weight, postweaning ADG, yearling weight and weaning and yearling conformation score. Weaning weights were standardized to a 205-day mature dam basis using additive correction factors of +84 pounds, +37 pounds and +5 pounds for calves from 2, 3 and 4-year old dams, respectively. The correction factors used were developed in an earlier study involving a substantial portion of this same data (Cardellino and Frahm, 1970, Okla. Agr. Exp. Sta. Misc. Pub. 84:5). Yearling weights were 365-day weights for bulls obtained by multiplying 160 times postweaning ADG and adding the adjusted weaning weight. Yearling weights for heifers were 425-day weights obtained by multiplying 220 times postweaning ADG and adding the adjusted weaning weight.

Selection differentials, the difference in the performance of the selected individual compared with the average performance of the group from which it was selected, were used to measure the amount of selection applied. In closed herds under long term selection, selection differentials accumulate over time since calves selected in a given year may be offspring of parents that were also selected. Therefore, to measure the total amount of selection applied in the lines, a cumulative selection differential was calculated for each selected animal. The cumulative selection differential for an individual was the average of the cumulative selection differentials of its parents plus the individual's own selection differential. A cumulative selection differential quantitifies the total selection pressure applied to a particular selected animal relative to the original foundation herd. Foundation animals have cumulative selection differentials of zero.

Estimates of genetic changes were obtained from comparisons of performance of calves produced by foundation sires with performance of calves produced by selected sires. Semen that had been collected and stored from two foundation sires and semen from four selected bulls (two from WWL and two from YWL) born in 1970 was used to inseminate a herd of Angus cows to produce calves in 1972. The four selected sires represent the product of seven years of selection. A total of 103 calves, 61 steers and 42 heifers, were produced by these matings.

Results and Discussion

Time Trends

To establish the trends in average performance of the lines over the duration of this study, annual means for weaning weight, yearling weight and weaning and yearling conformation score are plotted on year in Figures 1, 2 and 3, respectively. Bull and heifer performances were averaged for determining the yearly average performances. Although there has been considerable fluctuation in performance from one year to the next, the average weaning weight, yearling weight and conformation scores have been quite similar for the two lines. Since the two lines are managed together under the same environmental conditions each year,

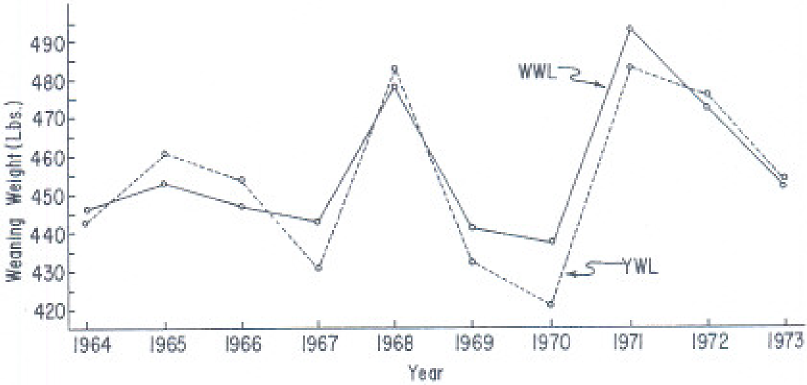

Figure 1. Annual Weaning Weight Means Plotted on Year.

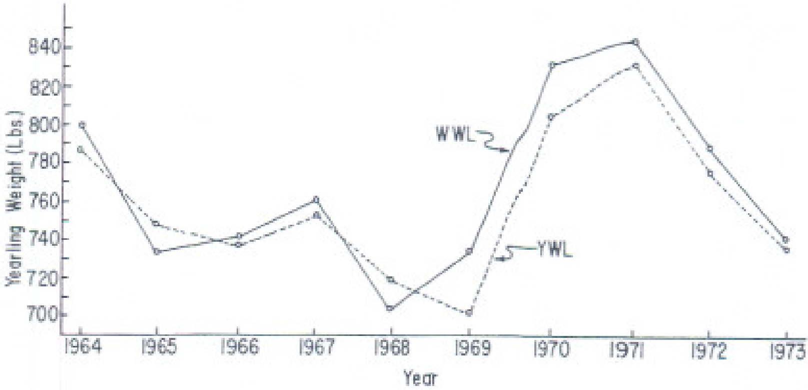

Figure 2. Annual Yearling Weight Means Plotted on Year.

the environmental effects in any year would be expected to be very similar on both lines. Thus, the close agreement in performance through yearling age for the two lines suggest that the genetic improvement to date for weaning weight and yearling weight has been quite similar in both lines.

Annual changes in performance were determined by calculating the regression coefficients of yearly means on years for each of the traits. The regression coefficients obtained are summarized in Table 1 and measure the average change in performance per year. These changes, as well as the yearly changes shown in Figures 1, 2 and 3, are the combined result of genetic and environmental changes. Consequently, interpretation of these results in terms of quantifying genetic responses to selection is not possible.

Table 1. Coefficients Of Regression Of Average Annual Performance On Year

Trait	Weaning Weight Line	Yearling Weight Line
Birth Weight (ls.)	0.0±0.26	0.0±0.44
Weaning Weight (lbs.)	2.2±2.01	1.6±2.52
Weaning Score[1]	0.1±0.04	0.1±0.04
Postweaning ADG (lbs./day)	0.0±0.03	0.0±0.03
Yearling Weight (lbs.)	3.9±5.22	2.2±4.7
Yearling Score[1]	0.1±0.05	0.1±0.05

[1] A 17 point scoring system was used where 13 = average choice, 14 = high choice, etc.

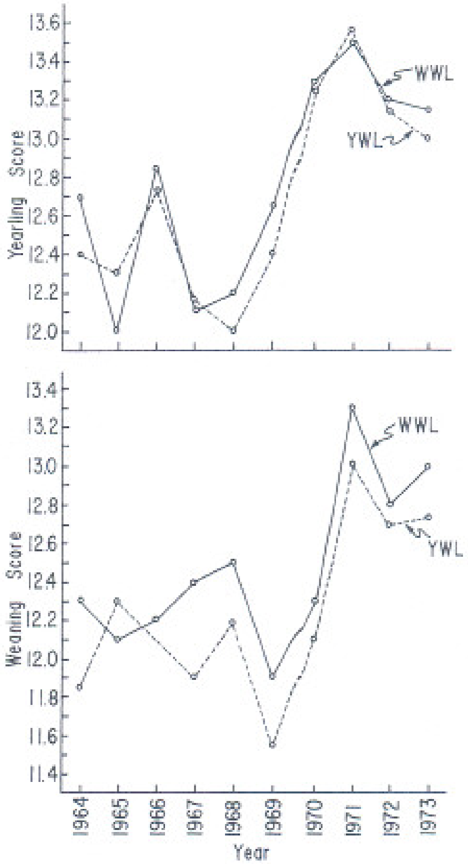

Figure 3. Annual Weaning and Conformation Score Means Plotted on Year

There was considerable year to year fluctuation in average weights in the two lines. On the average, weaning weight increased 2.2 pounds per year in the WWL and 1.6 pounds per year in the YWL. Yearling weight increased an average of 3.9 pounds per year in the WWL and 2.2 pounds per year in the YWL. The regression coefficients reinforce the apparent similar genetic responses that have occurred in these two lines.

Concern has been expressed by some cattlemen that intense selection for growth performance will result in deterioration of conformation. Therefore, it is of interest to evaluate time trends in weaning and yearling conformation score in these lines. The plots in Figure 3 indicate that substantial improvement in average conformation was realized over the years studied, though there was some year to year variation. Although these results can not be attributed totally to genetic causes, selection for growth performance in these lines apparently has resulted in improved conformation rather than a deterioration in conformation.

Selection Applied

Generation interval, the average age of the parents when the calves are born, affects the rate of progress from selection since it is the interval of time needed to complete a cycle of selection. Average age of the parents was similar in the two lines, averaging 4.1 years in both lines. The average ages indicate that generation intervals were somewhat shorter than generally observed in beef cattle herds. The shorter generation intervals were due primarily to higher annual replacement rates in the lines than normally found in commercial herds and the use of yearling age bulls.

In beef cattle herds there is considerable overlap in generations producing calves in any year. Generations of selection were measured in this study by calculating generation coefficients for each calf crop. The coefficients measured the average number of generations or cycles of selection that had been practiced in the ancestry of the calves born in any given year. By 1973 an average of 2.0 and 2.1 generations of selection had been practiced in the WWL and YWL, respectively.

The amount of selection applied was measured by total cumulative selection differentials of the parents of each calf crop. Total cumulative selection differentials include the selection differentials of parents, plus the average selection differentials of the parents from previous generations and measure the total amount of selection applied from the time selection was initiated. In a herd under long term selection, the total cumulative selection differentials of both sires and dams are the combied result of male and female selection in previous generations. A larger proportion of the females must be kept each year for replacements, consequently the cumulative intensity of male selection would be expected to be much larger than the cumulative effects of female selection. To independently measure the amount of selection realized from male and female selection, respectively, the total cumulative selection differentials were partitioned into two components, a male cumulative selection differential and a female cumulative selection differential.

Weaning weight and yearling weight were the selection criterion in the WWL and YWL, respectively. Consequently, intensity of selection for these traits is of primary interest. Table 2 summarizes male, female and total cumulative selection differentials for weaning weight in the WWL and yearling weight in the YWL. Increase in total cumulative selection differentials was quite regular for both weaning weight and yearling

Table 2. Male, Female And Total Cumulative Selection Differentials For Weaning Weight And Yearling Weight

Year	Weaning Weight Cumulative Selection Differentials[1] (lbs.)			Yearling Weight Cumulative Selection Differentials[2] (lbs.)		
	Male	Female	Total	Male	Female	Total
1964-1965	0	0	0	0	0	0
1966	0	1.4	1.4	0	2.2	2.2
1967	7.4	4.5	11.9	37.1	3.3	40.4
1968	24.2	2.5	26.7	63.5	3.8	67.3
1969	30.9	6.4	37.3	57.3	7.9	65.2
1970	30.6	8.5	39.1	91.7	13.2	104.9
1971	45.2	11.0	56.2	129.3	14.7	143.9
1972	62.5	13.3	75.8	138.3	22.7	161.0
1973	78.5	19.7	98.2	162.2	34.1	196.3

[1] Weaning weight selection differentials from weaning weight line.
[2] Yearling weight selection differentials from yearling weight line.

weight. By 1973, total cumulative selection differentials of 98.2 pounds for weaning weight in the WWL and 196.3 pounds for yearling weight in the WWL had been obtained. These results indicate that appreciable selection was accomplished for both weaning weight and yearling weight and suggest that positive genetic responses should be expected from selection.

In 1973, the total cumulative selection differential of 98.2 pounds for weaning weight in the WWL was made up of a male cumulative selection differential of 78.5 pounds and a female cumulative selection differential of 19.7 pounds. Thus, male selection accounted for 80 percent of the total selection for weaning weight. In like manner, male and female cumulative selection differentials for yearling weight in the YWL in 1973 were 162.2 and 34.1 pounds, respectively, for a total cumulative selection differential of 196.3 pounds. Thus, of the total selection for yearling weight, 83 percent was due to male selection. These results support the often quoted phrase "that from 80 to 90 percent of the genetic improvement made is the result of sire selection" and emphasize the importance of sire selection and evaluation.

Table 3 summarizes cumulative correlated selection differentials for birth weight, weaning weight, postweaning ADG, yearling weight and weaning and yearling conformation scores. It is important to evaluate correlated selection differentials for these traits since total improvement in productivity is influenced by changes that may occur in these traits as a correlated response to selection for increased weaning of yearling weight. Of particular interest is correlated cumulative selection differentials for yearling weight in the WWL. If animals with the heaviest weaning weights have above average yearling weights, also, considerable savings in feed costs could be realized by being able to cull some animals at weaning rather than waiting until all animals reach a year of age.

In 1973 the yearling weight cumulative selection differential in the WWL was 130.0 pounds. In the YWL in 1973 the total cumulative selection differential for yearling weight was 196.4 pounds (Table 2). Thus, when selection was based on weaning weight, correlated selection differentials for yearling weight were 66 percent as large as cumulative selection differentials obtained by direct selection for yearling weight. These figures indicate that those animals selected on the basis of heavy weaning weights had above average yearling weights and suggest that weaning weight is a fairly good indicator of yearling weight. Thus, considerable culling on the basis of weaning weight could be practiced with small likelihood of culling animals with the potential for above average yearling weight.

In 1973 the correlated cumulative selection differential for weaning weight in the YWL was 94.0 pounds and was 92 percent as large as the total cumulative selection differential of 98.2 pounds obtained in the WWL. Thus, correlated selection for weaning weight was almost as intense when selection was based on yearling weight as when selection was based on weaning weight.

The data summarized in Table 3 indicate that positive correlated selection differentials were obtained for birth weight, postweaning ADG and weaning and yearling conformation scores in both lines. Correlated selection for birth weight may not be advantageous because of the potential increase in calving difficulty and subsequent calf losses that may be associated with increased birth weight. Correlated selection for postweaning ADG was more intense in the YWL than in the WWL. This likely would be expected because of the large effect postweaning ADG has on yearling weight. Although not large, positive correlated selection differentials were obtained for weaning and yearling conformation score. As a

Table 3. Total Correlated Cumulative Selection Differentials After Nine Years Of Selection

Trait	Weaning Weight Line	Yearling Weight Line
Birth Weight (lbs.)	9.9	11.2
Weaning Weight (lbs.)	--	94.0
Weaning Score[1]	1.3	0.7
Postweaning ADG (lbs./day)	0.2	0.6
Yearling Weight (lbs.)	130.0	--
Yearling Score[1]	1.0	0.8

[1] A 17 point scoring system was used where 13 = average choice, 14 = high choice.

result conformation would be expected to improve slightly as a result of selection for weaning weight or yearling weight rather than deteriorate as suggested by some.

The positive correlated selection differentials obtained in both selection lines indicate that improvement in total growth performance from birth to yearling age can be expected from selection for either weaning weight or yearling weight. However, the intensity of correlated selection for weaning weight and postweaning ADG in the YWL suggests that selection for yearling weight should result in more improvement in total growth performance than selection for weaning weight.

Response to Selection

Differences in performance of calves produced by foundation and selected sires were used to estimate genetic response to selection. As discussed previously, semen from two foundation sires and the four selected sires from the 1970 calf crop was used to produce calves in an Angus herd in 1972. The data collected on the calves was statistically analyzed by least squares procedures and is summarized in Table 4. The least squares means presented have been adjusted for unequal numbers of calves of the two sexes and different numbers of calves from each bull producing calves in the two sire comparison groups. The selected sires were considered together in these comparisons. That is, no differentiation was made between calves from the WWL bulls and calves from the YWL bulls since performance of the two lines was very similar over the years studied.

The data indicates that calves produced by selected sires weighed 29 pounds more at weaning and were 54 pounds heavier at yearling age than calves produced by foundation sires. In addition, selected sires' calves averaged 3.7 pounds heavier at birth and gained 0.2 pounds more per day postweaning than calves from foundation sires. Differences in conformation at weaning were not large and yearling conformation scores were not obtained with these cattle.

Table 4. **Least Squares Means And Standard Errors For Progeny Produced By Foundation And Selected Sires**

Trait	Foundation Sires	Selected Sires	Difference
Number of progeny	56	47	
Birth Weight (lbs.)	66.6 ± 1.11	70.3 ± 1.78	3.7 ($P < .10$)
Weaning Weight (lbs.)	490.0 ± 5.18	519.0 ± 8.30	29.0 ($P < .01$)
Weaning Score[1]	13.0 ± 0.09	13.5 ± 0.14	0.1 (NS)
Postweaning ADG (lbs./day)	1.8 ± 0.05	2.0 ± 0.08	0.2 ($P < .10$)
Yearling Weight (lbs.)	778.0 ± 18.43	832.0 ± 29.5	54.0 ($P \sim .25$)

[1] A 17 point scoring system was used where 13 = average choice, 14 = high choice, etc.

It would have been desirable to measure genetic response in terms of annual changes in average line performance. This was not possible with this data since the selected sires were the top bulls from the two lines and improvement in the cow herd was not considered. However, the results of the foundation vs. selected sires comparisons suggest that positive genetic responses were obtained from selection since seven years of selection resulted in sires capable of producing calves which were 5.6, 5.9 and 6.9 percent heavier at birth, weaning and yearling age and grew 11 percent faster postweaning than calves produced by foundation sires.

The magnitude of the cumulative selection differentials discussed previously indicates that appreciable selection was applied in both selection lines. Thus, positive genetic responses were expected. The foundation vs. selected sires comparisons indicate that positive genetic responses were obtained as a result of selection while time trends in average line performance suggest that on a per year basis the changes were small in magnitude. Although annual genetic responses apparently are small, the cumulative nature of selection indicates that over time appreciable improvement in performance should result from selection based on weaning weight or yearling weight.

Supplemental Value of Urea and Feed Grade Biuret for Heifers Wintered on Dry Range Grass

Jack G. Wright, W. E. Sharp, Mervin Compton and Robert Totusek

Story in Brief

Two winter trials were conducted to evaluate the supplemental value of urea and feed grade biuret for beef replacement females grazing low quality winter forage (dry range grass).

Yearling, crossbred replacement heifers were fed supplements containing (1) 30 percent natural protein (positive control), (2) 15 percent natural protein (negative control), (3) urea, and (4) feed grade biuret. Each non-protein-nitrogen (NPN) source (urea and biuret) furnished one-half of the supplemental nitrogen. The positive control heifers lost

less weight than the negative control heifers, indicating need for more protein than supplied by the negative control. Weight loss of urea heifers was midway between the positive and negative controls, with an apparent urea utilization of 52 percent. Biuret heifers lost slightly more weight than urea heifers, with an apparent utilization of biuret of 30 percent.

Weaned, crossbred replacement heifers were fed supplements containing (1) natural protein (positive control), (2) no supplemental nitrogen (negative control), (3) urea, and (4) feed grade biuret. Each NPN source (urea or biuret) furnished about 98 percent of the supplemental nitrogen. The positive control heifers lost considerably less weight than the negative controls. Urea and biuret heifers sustained a weight loss midway between the controls, suggesting appreciable utilization of the NPN. However, intake of NPN supplements was too low to support satisfactory winter performance of heifers.

Introduction

Low quality forages are used extensively for wintering beef cattle and supplementation with protein is usually needed for satisfactory performance. The use of NPN in range supplements has increased in recent years. This trend will probably continue as a larger amount of natural protein will be used for human consumption in the future. Research has shown, in experiments involving beef cattle wintered on low quality native range grass in Oklahoma, that urea-containing supplements are of much lower value than supplements containing natural protein due to poor utilization of urea.

The purpose of this study was to compare NPN supplements (NPN furnishing 50 and 98 percent of the total nitrogen) to supplements of natural protein for heifers wintered on dry range grass.

Procedure

Two trials were conducted at the Lake Carl Blackwell Range located 10 miles west of Stillwater. The predominant forage was of the tallgrass prairie type with climax species consisting of little bluestem, big bluestem, Indian grass, and switch grass. Number and ingredient makeup of supplements is shown in Table 1.

Trial 1.

Sixty-six crossbred (½ Charolais X ½ Angus, ½ Charolais X ½ Hereford, ½ Hereford X ¼ Angus X ¼ Holstein), pregnant yearling heifers were allotted to four treatment groups for a 77-day wintering trial. Treatments 1 and 2, positive and negative controls, consisted of 30 and 15 percent natural protein supplements (supplements 1 and 2, Table 1). Treatment 3 consisted of a 30 percent crude protein supplement with one-half of the nitrogen from urea and treatment 4 consisted of a 30 percent crude protein supplement with one-half of the nitrogen from biuret and urea (feed grade biuret) (supplements 3 and 4, Table 1).

Alfalfa hay was included at a level of 40 percent of the urea and biuret supplements because of previous indications that NPN utilization is improved by a high level of alfalfa. Supplements were supplied free-choice in mineral feeders with salt added to limit intake. Salt comprised 30 percent of the total as-fed mixture for treatments 1 and 2 and 20 percent for treatments 3 and 4. Equal intake of non-salt supplement among the four treatments was achieved. Heifers were rotated among pastures at 14-day intervals.

Trial 2.

Eighty crossbred (as described for trial 1) and Hereford weaned heifer calves were allotted to four treatments for a 90-day wintering trial. The first treatment served as the positive control and consisted of a 30 percent natural protein supplement (supplement 1, Table 1); salt was added at an average level of 30 percent to limit intake. The second treatment served as the negative control and consisted only of a mineral mixture of 50 percent dicalcium phosphate and 50 percent trace mineral salt

Table 1. Ingredient Makeup of Protein Supplements (Percent)

	Supplement number, description and % crude protein[1]					
	1 Natural 30	2 Natural 15	3 Urea-Alfalfa[2] 30	4 Kedlor-alfalfa[2,3] 30	5 Urea-mineral[2] 107	6 Kedlor-mineral[2,3] 105
Corn	27.77	68.75	28.96	24.51	20.00	10.00
Soybean meal, sol (44%)	58.25	17.25	13.05	13.94	----	----
Ground alfalfa hay	5.00	5.00	40.00	40.00	----	----
Molasses, sugarcane	5.00	5.00	5.00	5.00	----	----
Monosodium phosphate	2.50	2.75	3.60	3.60	11.79	8.76
Dicalcium phosphate	0.75	1.20	----	----	6.97	5.58
Sodium sulfate[4]	0.68	----	4.00	4.00	13.80	11.94
Trace mineral mix	0.05	0.05	0.05	0.05	0.17	0.15
Vitamin A[5]	+	+	+	+	—	—
Urea	----	----	5.34	----	37.27	----
Kedlor 250[3]	----	----	----	8.90	----	53.57
Salt	----	----	----	----	8.00	8.00
Magnesium oxide	----	----	----	----	2.00	2.00

[1] Approximate crude protein as determined by feed composition tables, Crampton and Harris (1969).
[2] NPN source provided 50% of crude protein equivalent for urea and/or biuret.
[3] Kedlor 250, feed grade biuret, approximate chemical composition (dry weight basis): Biuret 60% urea 15%, cyanuric acid 21%, and total nitrogen 37%.
[4] Formulated to supply 12:1 nitrogen: sulfur ratio.
[5] 10,000 IU per pound of supplement.

with no nitrogen included. The third treatment consisted of a biuret-mineral supplement with a high (107 percent) crude protein equivalent supplied by urea (supplement 5, Table 1). The fourth treatment consisted of a feed grade biuret from feed grade biuret (supplement 6, Table 1).

Ground corn (at levels of 20 and 10 percent) and salt (8 percent) were included in the NPN-mineral supplements to encourage intake. Since the NPN-mineral supplements absorbed enough moisture to become very wet, magnesium oxide (2 percent of the supplements) was added to lower hygroscopicity to a satisfactory level. All supplements were fed free-choice in mineral feeders. Intake of the natural protein supplement was limited to equal the nitrogen intake of the urea supplement; nitrogen intake of the biuret supplement was substantially lower than for natural and urea supplements. Heifers were rotated among pastures at 14-day intervals.

Results and Discussion

Trial 1.

Results are presented in Table 2. Daily intake of supplemental protein was the same for all groups. Heifers fed the 30 percent natural protein supplement (positive control) lost less weight than heifers receiving the 15 percent natural protein supplement (negative control), demonstrating the need for more protein than supplied by the negative control. Weight loss of urea-supplemented heifers was midway between positive and negative controls, suggesting an apparent urea utilization of 52 percent. Weight loss of biuret-supplemented heifers was slightly greater than that of urea-supplemented heifers, with an apparent utilization of 30 percent. The level of apparent urea utilization in this trial, with a self-fed supplement containing a high level of alfalfa, was the highest observed on this experimental winter range.

Table 2. Performance of Yearling Heifers During Winter Supplementation Period in Trial 1.

Item	Supplement, % crude protein			
	Natural 30	Natural 15	Urea-Alfalfa 30	Kedlor-Alfalfa 30
No. heifers	16	17	16	17
Daily non-salt supplement intake, lb.	2.05	2.05	2.05	2.05
Daily crude protein intake, lb.	0.62	0.31	0.62	0.62
Initial weight, lb.	723	746	735	736
Weight loss, lb.	28	49	38	43
Weight loss, %	3.9[1]	6.6[2]	5.2[1,2]	5.8[2]

[1,2] Values with different superscripts differ significantly (P<.05).

Trial 2.

Performance data are presented in Table 3. Heifers fed the 30 percent natural protein supplement (positive control) lost less weight than those which received no protein supplement (negative control). NPN-supplemented heifers sustained weight losses intermediate between the control groups, but the NPN supplements were not different from each other in weight loss. Supplemental nitrogen intake by positive control and urea groups was similar; intake of the positive control supplement was restricted to that of the urea supplement. Nitrogen intake by the biuret heifers was only one half that of the urea group, so their similar weight loss was somewhat surprising.

The weight loss of the urea-fed heifers was midway between the weight loss of positive and negative control with an apparent utilization of urea nitrogen of 53 percent. Although the weight loss of biuret supplemented heifers was similar to that of urea supplemented heifers, a valid estimate of nitrogen utilization from feed grade biuret was not possible because nitrogen intake was not comparable. The intake of both high NPN supplements in this trial was not sufficient to sustain a satisfactory level of perfarmance by the heifers.

Table 3. Performance of Weaned Heifers During Winter Supplementation Period in Trial 2.

Item	Supplement, % crude protein			
	Natural 30	No Nitrogen supplement	Urea-mineral 107	Kedlor-mineral 105
No. heifers	20	20	20	20
Daily non-salt spplement intake, lb.	0.7	----	0.21	0.11
Daily crude protein intake, lb.	0.21	----	0.22	0.12
Initial weight, lb.	505	503	503	502
Weight loss, lb.	87	122	103	107
Weight loss, %	17.2[1]	24.2[2]	20.5[2]	21.3[1]

[1,2] Values with different superscripts differ significantly (P<.05).

Supplemental Value of MHA for Range Cows

Jack G. Wright, W. E. Sharp, Mervin Compton and Robert Totusek

Story in Brief

A winter trial was conducted to evaluate the supplemental value of methionine-hydroxy-analogue (MHA) for beef cows grazing dry native range grass.

Pregnant-lactating crossbred cows were fed a 30 percent natural protein supplement with or without MHA. Among the cows that calved before MHA feeding began, those fed MHA lost more weight and condition than those fed no MHA. Calves of winter MHA supplemented cows gained faster during the subsequent summer and were 12 lb. heavier at weaning.

Among cows that calved after MHA feeding began, those supplemented with MHA had calves that gained faster during the winter and weighed 18 lb. more at weaning.

Introduction

In Oklahoma, many beef cows subsist on dry range grass during the winter months and supplementation with protein is needed for satisfactory performance. In research at other locations MHA has improved milk production in both beef cows and dairy cows. Beef cows wintered on low quality forage are subjected to stress and lose weight in a pattern similar to that of high producing dairy cows.

The objective of this study was to evaluate MHA for lactating beef cows fed a natural protein supplement while grazing dry native range grass.

Procedure

This trial was conducted at the Lake Carl Blackwell Range located 10 miles west of Stillwater. The predominant forage is of the tall-grass prairie type with climax species consisting of little bluestem, big bluestem, Indian grass and switch grass.

Forty-seven mature Angus x Holstein cows were randomly allotted to two treatment groups for a 134-day wintering trial. Treatment 1 consisted of a 30% natural protein supplement. Treatment 2 consisted of the same supplement with MHA added. Ingredient makeup of the supplements is shown in Table 1.

Table 1. Ingredient Makeup of Protein Supplements (Percent).

Ingredient	Supplement	
	Natural 30	Natural 30 + MHA
Corn	27.77	27.77
Soybean meal, sol (44%)	58.25	58.24
Ground alfalfa hay	5.00	5.00
Molasses	5.00	5.00
Monosodium phosphate	2.50	2.50
Dicalcium phosphate	0.75	0.75
Sodium sulfate[1]	0.68	0.68
Trace mineral mix	0.05	0.05
Vitamin A[2]	+	+
MHA[3] premix	---	0.01

[1] Formulated to supply 12:1 nitrogen: sulfur ratio.
[2] 10,000 IU per pound of supplement.
[3] Methionine-hydroxy-analogue.

Supplements were fed at the rate of 3.43 pounds per cow daily for 40 days and 4.29 pounds for the remaining 94 days of the trial. Intake of MHA was 14 and 18 grams per cow daily, respectively, for the two periods. Initial and final condition of cows was estimated by scoring each cow on a scale of 1 to 9, with 1 being the thinnest and 9 the fattest. The cattle were rotated between pastures at 28-day intervals.

For purposes of analysis, each treatment group was divided into two subclasses to study the effects of calving date relative to initiation of MHA feeding. Cows that calved before treatment began had an average calving date of October 27; cows that calved after treatment began had an average calving date of December 25. The calving dates ranged from September 28 to February 11 for all cows. Calving was completed before the trial was ended.

Results and Discussion

Performance of cows and calves is shown in Table 2. Among cows that calved before treatment began, those supplemented with MHA lost more weight and condition than those without MHA. This was apparently not due to greater milk production because daily gain calves was identical during the winter supplementation period.

During the subsequent summer period calves of winter-MHA-supplemented cows gained significantly more and consequently were heavier at weaning; the difference in weaning weight was not significantly different.

Among cows that calved after treatment began, supplementation with MHA did not affect weight or condition of cows. Calves of MHA sup-

Table 2. Performance of Cows and Calves.

Item	Supplement	
	Natural 30	Natural 30 + MHA
	Cows calving before trial	
No. Cows	13	13
Average daily supplmeent, lb.	4.0	4.0
Cow		
Initial weight, lb.	1018	1050
Weight loss, lb.	110[1]	167[2]
Score change[3]	—1.8	—2.5
Calf		
Daily gain during winter, lb.	1.45	1.45
Daily gain during summer, lb.	2.22[1]	2.57[2]
Weaning weight, lb.	455	467
	Cows calving during trial	
No. cows	11	10
Average daily supplement, lb.	4.0	4.0
Cow		
Initial weight, lb.	1185	1152
Weight loss, lb.	245	237
Score change	—2.5	—2.6
Calf		
Daily gain during winter, lb.	1.72	1.94
Daily gain during summer, lb.	2.44	2.44
Weaning weight, lb.	507	525

[1,2] Values with different superscripts differ significantly ($P < .05$).
[3] Difference between initial and final condition based on a scale of 1 to 9, 1 the thinnest and 9 the fattest.

plemented cows gained slightly faster during the winter supplementation period, but summer gains of calves were identical. Calves of MHA supplemented calves were heavier at weaning.

MHA had no apparent affect on palatability of the supplement in this trial. In a previous trial at this station MHA decreased the palatability of NPN-containing supplements when individually fed cows had a limited time to consume supplements. No improvement in cattle performance was noted in the previous trial when MHA was added to NPN containing supplements. It is possible that an increase in milk production and calf gain from MHA supplementation is contingent upon a higher level of energy intake than that provided by dry range grass. It is also possible that the differences in calf gain and weaning weight were real differences, and feeding MHA for a longer period to more cows before calving would have had a greater advantage. It is also possible, based on other research that a smaller daily allowance of MHA (such as 10 grams per cow daily) would have been desirable.

Supplemental Value of Urea and Extruded Grain-Urea for Range Beef Cows

Jack G. Wright, W. E. Sharp, Mervin Compton and Robert Totusek

Story in Brief

A winter trial was conducted to evaluate the supplemental value of urea and extruded grain-urea for beef cows grazing dry native range grass.

Pregnant-lactating Angus and Hereford cows were fed 30 and 15% natural protein (positive and negative controls, respectively), urea, Starea 44, and Starea 70 supplements. Each non-protein-nitrogen (NPN) source furnished one-half of the supplemental nitrogen. Positive control cows sustained the smallest weight loss and negative control cows the greatest weight loss. Weight loss of NPN supplemented cows was intermediate. Apparent utilization of NPN was 36, 38, and 25 percent for urea; Starea 44 and Starea 70, respectively.

Introduction

Supplementation with protein is usually needed for satisfactory performance of beef cows wintered on dry native range. A summary of 16 experiments involving beef cattle wintered on native range grass in Oklahoma showed that urea-containing supplements were consistently of lower value than supplements containing natural protein. Since poor utilization of urea is caused in part by rapid break-down in the rumen, interest has developed in extruded grain-urea products because of their slower breakdown.

The objective of this study was to determine the value of extruded grain-urea compared to "conventional" urea and natural protein sources for lactating beef cows.

Procedure

The trial was conducted at the Lake Carl Blackwell Range located 10 miles west of Stillwater. The predominant forage was of the tall-grass prairie type with climax vegetation of little bluestem, big bluestem, Indian grass, and switch grass. Ingredient makeup of supplements is shown in Table 1.

One-hundred-four mature Angus and Hereford cows were randomly alloted to five treatments for a 113-day trial. Treatments 1 and 2, posi-

Table 1. Ingredient Makeup of Protein Supplements (Percent).

	Supplement number, description and % crude protein[1]				
	1	2	3	4	5
Ingredient	Natural 30	Natural 15	Urea[2]	Starea 44[2]	Starea 70[2]
Corn	27.77	68.75	59.35	23.32	41.35
Soybean meal, sol (44%)	58.25	17.25	19.25	16.30	18.45
Ground alfalfa hay	5.00	5.00	5.00	5.00	5.00
Molasses, sugarcane	5.00	5.00	5.00	5.00	5.00
Monosodium phosphate	2.50	2.75	2.85	2.80	2.80
Dicalcium phosphate	0.75	1.20	1.17	1.18	1.15
Sodium sulfate[3]	0.68	---	2.03	2.10	2.05
Trace mineral mix	0.05	0.05	0.05	0.05	0.05
Vitamin A[4]	+	+	+	+	+
Urea[2]	---	---	5.30	---	---
Starea 44[2,5]	---	---	---	44.25	---
Starea 70[2,5]	---	---	---	---	24.15

[1] Approximate crude protein as determined by feed composition table, Crampton and Harris (1969).
[2] Urea and the urea portion of Starea products to furnish 50% of total crude protein.
[3] Formulated to supply 12:1 nitrogen:sulfur ratio.
[4] 10,000 IU per pound of supplement.
[5] Gelatinized grain-urea mixture.

tive and negative controls, respectively, consisted of 30 and 15 percent natural protein supplements. Treatments 3, 4, and 5 consisted of 30 percent crude proteins supplements in which one-half of the nitrogen was provided by urea (treatment 3) and urea within starea 44 and starea 70 (treatments 4 and 5). Starea 44, containing 44 percent crude protein equivalent, consists of 13 percent urea and 87 percent milo. Starea 70, containing 70 percent crude protein equivalent, consists of 22 percent urea and 78 percent milo.

Cows, allowed to graze in a common pasture, were gathered to a central feeding area each morning six days per week, placed in 3 X 8 feet stalls located in a shed and individually fed their supplement. Twenty minutes was allowed for consumption of supplement. Feed refusals were recorded daily, and intake adjustments were made periodically to maintain equal intake of supplement among all treatments. Supplement intake, lower than desired, was dictated by the level of NPN supplements which the cows would consume during the individual feeding period.

Cows calved from September 28 to February 16, with an average calving date of November 21. Calving was completed before the trial was ended. Initial and final condition of cows was estimated by scoring each cow on a scale of 1 to 9, with 1 being the thinnest and 9 the fattest.

Since the number of cows which calved prior to the trial was disproportionate among treatments, initial weight of the cows that had calved before the trial was adjusted to a pregnant weight basis with the following formula:

Adjusted initial weight = actual initial weight + (calf birth weight x 1.9697 — 19.0).

Results and Discussion

Results are presented in Table 2. Average daily supplement intake per cow was 2.5 pounds for all groups. Cows fed the 30 percent natural protein supplement, the positive control, lost less weight than cows fed the 15 percent protein supplement, the negative control. This indicated that the negative control was low in protein and provides a valid basis of comparison for the NPN supplements. Weight loss of cows fed the NPN-containing supplements was intermediate between positive and negative control. Weight loss expressed as a percentage of initial weight provides a more valid comparison of supplements due to variation in initial weight among treatments. On this basis none of the NPN-containing supplements were significantly different from the negative control.

Weight loss of NPN-supplemented cows can be compared to the weight loss of negative and positive control cows to provide an estimate of the apparent utilization of the NPN. Such a comparison shows an apparent utilization of 36, 38, and 25 percent for urea, Starea 44 and Starea 70, respectively.

Negative control cows lost more condition than positive control cows, consistent with the difference in weight loss. Condition loss of NPN-

Table 2. Performance of Cows and Calves During Winter Supplementation Period.

	Supplement, % crude protein				
Item	Natural 30	Natural 15	Urea[1] 30	Starea 44 30	Starea 70 30
No. cows	21	21	20	21	21
Daily supplement, lb.	2.5	2.5	2.5	2.5	2.5
Daily crude protein intake, lb.	0.75	0.37	0.75	0.75	0.75
Initial weight, lb.	1037	1110	1094	1049	1067
Weight loss, lb.	238	362	336	321	334
Weight loss, %	27.3[1]	32.6[2]	30.7[2]	30.6[2]	31.3[2]
Condition score change[3]	—1.8[1]	—2.8[2]	—2.5[1,2]	—2.6[2]	—2.4[1,2]
Calf weight gain, lb.	107	71	105	95	98

[1,2] Means in the same row with different superscripts differ significantly ($P \leq .05$).
[3] Difference in initial and final condition based on a scale of 1 to 9, with 1 being the thinnest and 9 the fattest.

supplemented cows, intermediate between the controls, was closer to that of negative controls.

Weight and condition loss comparisons in this trial indicated a low utilization of the NPN portion of the supplements, consistent with previous results obtained in the same area on similar dry winter range grass. In a previous trial, utilization of urea was greater than an extruded grain-urea product, but utilization of the extruded grain-urea products used in this trial (starea 44 and starea 70) was similar to urea.

Positive control calves gained significantly more than negative control calves. However, gains of calves in NPN-supplemented groups were not significantly different from positive controls, and significantly different from negative controls in only one case (urea). A lack of effect of supplement treatments on calf gain, even though weight loss of cows was affected, has been observed at this station. In short duration trials of this nature cows probably maintain milk production at the expense of body tissues.

Performance of Five-Year-Old Hereford, Hereford X Holstein and Holstein Females as Influenced by Level of Winter Supplementation Under Range Conditions

R. D. Wyatt, K. S. Lusby, L. Knori, Mike Gould, and Robert Totusek

Story in Brief

The performance of winter calving, 5-year-old Hereford, Hereford x Holstein and Holstein females under tallgrass range conditions was compared. Two levels of winter supplementation were imposed on groups within each breed at calving and extended through the winter.

As the level of winter supplement increased, winter weight loss decreased for cows in the Hereford x Holstein breed group. This trend was not evident in the Hereford and Holstein breed groups due to the increased lactation interval during the winter in treatments receiving the

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In cooperation with USDA, Agricultural Research Service, Southern Region.

higher supplement levels. Cows in the Holstein treatment groups did not effectively regain winter weight losses during the summer grazing period. Condition scores followed trends similar to winter weight losses and summer gains. Daily milk yields for Hereford, Hereford x Holstein and Holstein females were 14, 21, and 28 lb/day, respectively. Birth weights were 81.5, 84.5 and 102.5 lb., and weaning weights were 604, 658 and 763 lb., respectively. Low rebreeding performance was observed in the High Hereford x Holstein and Holstein groups and also in the Very High Holstein group.

Introduction

Increasing the weaning weight of calves is a principal goal in most commercial cow-calf enterprises. Weaning weight is one of the most important considerations in beef production, but we must not overlook the importance of the efficiency with which increases are attained. In most production situations, selection for increased weaning weight automatically results in selection for increased milk production because of the strong relationship between level of milk production of cows and weaned weight of the calf. The most rapid method of increasing milk production is by infusing genes for high milking ability from dairy animals.

The conversion of milk to calf gain is a rather efficient process within the limits of milk production in the beef cow. Within this range, the conversion is approximately 10 lb. of milk per lb. of gain. Preliminary data indicate that this conversion may not be as efficient at high levels of milk production. Increasing the level of milk production in the beef cow will be accompanied by increased feed requirements of the cow and may decrease the efficiency of beef production. The purpose of this study was to determine the influence of varying levels of winter supplementation on actual milk yield, calf performance and reproductive efficiency of range brood cows differing widely with milk production potential.

Procedure

Groups of Hereford, Hereford x Holstein and Holstein females have been maintained continuously under native tallgrass range conditions at the Fort Reno Livestock Research Station since they were one year old. Since first calving, groups of the Hereford and Hereford x Holstein females have been subjected to two levels of winter supplementation (Moderate and High) while three supplement levels have been fed to the Holsteins (Moderate, High and Very High).

The Moderate level consisted of that amount of winter supplemental feed necessary to allow good rebreeding performance in the Hereford females. Previous experience at the Ft. Reno Station suggested a winter weight loss (including weight loss at calving) from fall to spring of 15 to 20 percent for mature cows.

The high level of winter supplement was established by the Hereford x Holstein females and consisted of that amount of supplement adequate to maintain a body condition and physiological activity comparable to the Moderate Herefords. Moderate and High levels were fed to groups of Hereford, Hereford x Holstein and Holstein females. An additional group of Holsteins received a Very High level of supplement. This level was calculated to maintain Holstein females in body condition similar to the Moderate Herefords and High Hereford x Holstein. This level was fed only to Holsteins.

The base breed treatment groups were the Moderate Hereford, High Hereford x Holstein and Very High Holstein females. These groups were fed (post calving) 2.6, 5.5 and 7.7 lb/head/day as 2-year-olds, 3.1, 6.3 and 9.2 lb/head/day as 3-year-olds and 2.7, 5.8 and 8.4 lb/head/day as 4-year-olds of a 30 percent crude protein supplement, respectively. As 5-year-olds they were fed 3.44, 5.65 and 7.81 lb/head/day, respectively. Within each nutritional treatment, the quantity of supplement fed each female was adjusted for difference in body size. Supplement intake by treatment and breed is summarized in Table 1.

The females were bred to Angus bulls as yearlings, and to Charolais bulls as 2, 3 and 4-year-olds. Kropp *et al.* (1972, MP-87) summarized their performance as 2-year-olds. Data from females as 3year-olds was reported by Holloway *et al.* (1973, MP-90) and performance as 4-year-olds was summarized by Lusby *et al.* (1974, MP-92). This report is relative to their performance as 5-year-olds. The 4-year-old females were artificially inseminated to one Charolais bull for 60 days and pasture exposed for 30

Table 1. Supplement Intake.

	Hereford		Hereford x Holstein		Holstein		
Item	Moderate	High	Moderate	High	Moderate[1]	High	Very High
Supplement, lb.[2]							
Total, winter[3]	337	577	349	604	--	514	848
Daily, pre-calving	0.64	1.28	0.57	1.26	--	1.15	1.68
Daily, post-calving	3.44	5.49	3.23	5.65	--	5.61	7.81

[1] No moderate Holstein treatment on range this year due to low rebreeding performance of cows the previous year.
[2] Soybean meal (44%), 60.1%; milo, ground, 30.3%; dehydrated alfalfa meal, 5.0%; dicalcium phosphate, 2.9%; Masonex, 13.0%; salt, 0.5%; plus vitamin A added at 10,000 IU/lb. of supplement.
[3] November 26, 1973 to April 16, 1974.

days to Charolais bulls.

Monthly individual cow weights (after 12-hour shrink) were taken from November, 1973 to October, 1974. Cow winter weight losses were calculated from November, 1973 to the lowest weight after calving (late April). Cow condition scores were taken prior to initiation, after termination, and before re-initiation of supplemental feeding. The scale for condition scores was 1 (very thin) to 9 (very fat).

All calves were weighted within 24 hours after birth and remained with their dams on native pasture until weaning; no creep was fed. During lactation, 24 hour milk production was estimated by the calf suckle technique. Milk production estimates were obtained in March, May and July.

Each calf was weaned at 240 ± 7 days of age. Weaning weights were adjusted to 240 days by interpolation or extrapolation. Age corrected weaning weights of heifer calves were adjusted to steer equivalent by multiplying by a factor of 1.05.

There was no Moderate Holstein treatment group this year due to the low rebreeding performance of cows receiving this level of supplement the preceeding year. All cows in this group which calved this year were needed in the drylot phase of the experiment.

Results and Discussion

Birth weights and 240 day sex-corrected weaning weights are presented in Table 2. Calves from Holstein cows were the heaviest at birth, averaging 103 and 102 lb. for High and Very High treatments, respective-

Table 2. Calving and Weaning Data.

	Hereford		Hereford x Holstein		Holstein		
Item	Moderate	High	Moderate	High	Moderate[1]	High	Very High
Number of calves weaned[2]	14	10	14	14	--	7	12
Male	4	6	7	6	--	5	10
Female	10	4	7	8	--	2	2
Calving date	1-18-74	1-4-74	1-5-74	1-9-74	--	1-28-74	1-5-74
Birth weight[3]	81	82	88	81	--	103	102
Adjusted weaning weight, lb.[4]	617	591	654	662	--	746	709

[1] No moderate Holstein treatment on range this year due to low rebreeding performance of cows the previous year.
[2] Calves weaned 240 ± 7 days.
[3] Birth weights not adjusted for calf sex.
[4] Weaning weights corrected for sex by multiplying heifer weaning weights by 1.05.

ly. Moderate and High Hereford x Holsteins averaged 88 and 81 lb., respectively. Moderate and High Herefords gave birth to calves averaging 81 and 82 lb., respectively. Level of winter supplement within each breed had little apparent influence on birth weight.

At weaning, calves from Hereford, Hereford x Holstein and Holstein cows weighed 604, 658 and 763 lb., respectively. Calf performance in previous years has indicated little influence of level of winter supplement of the dam on weaning weight. Apparent differences between weaning weights of calves within Hereford and Holstein breed treatment groups were probably a reflection of differences in birth dates (Table 2) which allowed heavier calves more time on lush summer pasture.

Cow Weight and Condition

The amount of winter weight loss within breed group decreased as the supplement level increased, however, the trend was not as marked as in the previous year. This was particularly evident within the Hereford and Holstein breed groups in which supplement level had little influence upon winter weight loss. The increased weight loss of High Hereford and Very High Holstein females may be attributed to the longer lactation in-

Table 3. Weight, Weight Change and Condition Score Data.

	Hereford		Hereford x Holstein		Holstein		
Item	Moderate	High	Moderate	High	Moderate[1]	High	Very High
No. head	14	13	14	14	—	7	12
Weight, lb.							
Fall, 1973 (pre-calving)	1023	1030	1047	1082	—	1183	1226
Spring, 1974 (mid-lactation)	884	864	838	899	—	983	1000
Fall, 1974 (post-lactation)	1083	1059	1089	1107	—	1172	1207
Weight change, lb.							
Winter	—139	—166	—209	—183	—	—200	—226
Summer	+179	+195	+251	+208	—	+189	+207
Year	+ 40	+ 29	+ 42	+ 25	—	— 11	— 19
Weight change, %							
Winter	— 13.6	— 16.2	— 19.9	— 17.0	—	— 16.9	— 18.4
Summer	+ 20.3	+ 22.6	+ 30.0	+ 23.1	—	+ 19.2	+ 20.7
Condition score[2,3]							
Fall, 1973	7.2	7.3	6.0	5.8	—	4.6	4.7
Spring, 1974	4.9	5.1	2.5	2.9	—	2.0	2.3
Fall, 1974	6.3	6.1	5.8	5.1	—	2.8	3.7

[1] No moderate Holstein treatment on range this year due to low rebreeding performance of cows the previous year.
[2] Condition score: very thin = 1, . . . , very fat = 9.
[3] Condition score based on those cows which weaned calves as 5-year-olds on range.

terval during the supplemental feeding period.

Average monthly cow weights are shown graphically in Figure 1. Weight losses between the first and third months may be largely attributed to calving weight losses. The lowest weights were observed during the second and third months of lactation.

As in previous years, condition scores generally reflected winter weight changes. Pre-calving condition scores did not appear to be influenced by the cows previous treatment. The lower pre-calving condition scores of Holstein breed groups suggests that both supplement levels (High and Very High) were inadequate for high producing females.

Milk Yields

Milk yields for 5-year-old Hereford, Hereford x Holstein and Holstein females are shown in Table 4. Level of winter supplement had no apparent affect on milk yield. Average milk yields for 5-year-old Hereford, Hereford x Holstein and Holstein females were 14, 21, and 28 lb/day, respectively. These groups produced 14, 20 and 27 lb/day as 4-year-olds; 14, 22 and 29 lb/day as 3-year-olds; and 13, 18 and 24 lb/day as 2-year-olds.

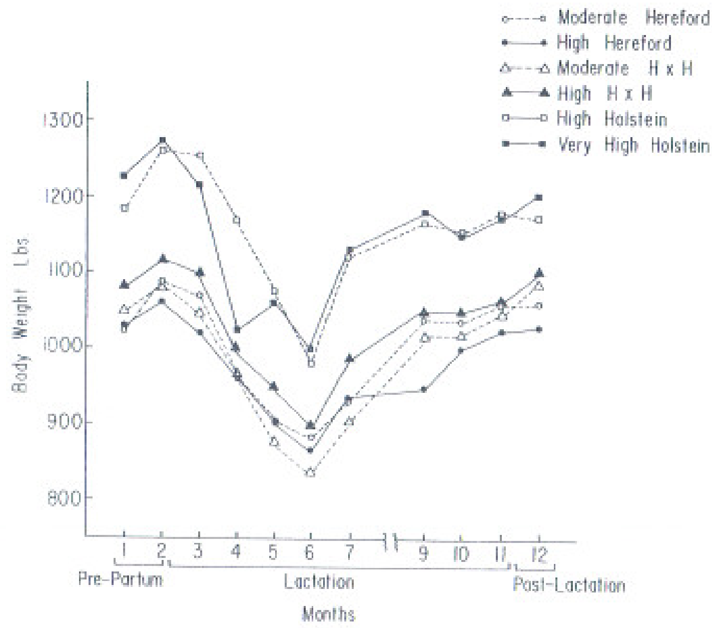

Figure 1. Body Weight Changes of Cows.

Table 4. Milk Production Data.

	Hereford		Hereford x Holstein		Holstein		
Item	Moderate	High	Moderate	High	Moderate[1]	High	Very High
Total lactation yield, lb.	3600	3120	4800	5280	—	6720	6720
Daily yield, lb.	15	13	20	22	—	28	28

[1] No moderate Holstein treatment on range this year due to low rebreeding performance of cows the previous year.

Reproductive Performance

Moderate and High Herefords and Moderate Hereford x Holstein females showed good rebreeding performance (Table 5). High Herefords x Holstein, High and Very High Holstein females did not maintain an adequate level of reproductive performance. Reasons for the low rebreeding performance of High Hereford x Holstein females (78.6 percent conception) are not readily apparent. Poor rebreeding performance among females in the High and Very High Holsteins (42.9 and 75.0 percent, respectively) may be due to the cumulative effects of a sub-optimal plane of nutrition for these high producing animals. Weight change and condition score data (Table 3) for females in these treatment groups indicate that the level of winter supplementation provided has not been adequate to meet their needs. As indicated previously, low rebreeding performance of the Moderate Holstein females resulted in their elimination as a range treatment group this year.

Table 5. Reproductive Performance.

	Hereford		Hereford x Holstein		Holstein		
Item	Moderate	High	Moderate	High	Moderate[1]	High	Very High
No. of females	15	13	16	14	—	7	12
No. of females bred	15	12	16	11	—	3	9
Rebreeding, % Conception	100.0	92.3	100.0	78.6	—	42.9	75.0
Days post-partum to apparent conception[2]	70	83	59	94	—	97	92

[1] No moderate Holstein treatment on range this year due to low rebreeding performance of cows the previous year.
[2] Based on service dates obtained from bulls fitted with chin-ball markers.

Economic Analysis

The economic analysis shown in Table 6 is based on Oklahoma 1974 prices. Different prices may be substituted as appropriate.

Several assumptions were employed in the economic analysis. Cost of native range was estimated at $85.00 per year per female for the Moderate Herefords. Individual roughage intakes were estimated in a drylot trial conducted concurrently and served as a basis for forage consumption of range cows. The percent of forage consumed (TDN basis) by each breed-treatment group in drylot compared to that of Moderate Herefords was multiplied by $85.00 to estimate the land cost of each group. The cost of supplement was estimated at $120.00 per ton.

The calves from the Hereford, Hereford x Holstein and Holstein females had an estimated value of $30.00, $29.00 and $27.00/cwt for steers with a $5.00/cwt discount for heifers. Estimated calf value was calculated by multiplying the adjusted 240-day weaning weight by their respective price/cwt and then calculating a weighted steer-heifer average. A sex distribution of 60 percent steers and 40 percent heifers was assumed for calves produced for sale.

As in previous years, the Holstein females weaned calves with the highest total value. However, adjustment for land and supplement costs removes this advantage. On the basis of return above land and supple-

Table 6. Economic Analysis.

	Hereford		Hereford x Holstein		Holstein		
Item	Moderate	High	Moderate	High	Moderate[1]	High	Very High
Land requirement, %[2]	100	101	117	103	—	141	133
Land cost/female, $	85.00	85.85	99.45	87.55	—	119.85	113.05
Supplement cost/female, $	21.06	36.06	21.81	37.75	—	32.13	53.00
Total land and supplement cost, $	106.06	121.91	121.26	125.30	—	151.98	166.05
Average value of calf, $	169.46	162.32	173.21	175.34	—	182.95	173.88
Return above land and supplement cost, $	63.40	40.41	51.95	50.04	—	30.97	7.83
Return adjusted for conception, $[3]	63.40	37.30	51.95	39.33	—	13.29	5.87

[1] No moderate Holstein treatment on range this year due to low rebreeding performance of cows the previous year.
[2] Expressed as % of Moderate Herefords as determined by forage intake in the drylot trial.
[3] Based on conception rate as 5-year-olds rebred for calving as 6-year-olds.

ment costs, it would appear that cows on the lower supplement levels yield the greatest return, $169.46 and $182.95 for the Hereford and Holstein breed treatment groups, respectively. In the Hereford x Holstein breed group, the higher supplement level showed the greatest return when expressed in this manner.

A more realistic profit picture is provided by adjusting for rebreeding performance. This adjustment was made by multiplying the return above feed cost per calf by percent conception of the cows as 5-year-olds. On this basis, Moderate Hereford females were the most profitable followed by Moderate Hereford x Holsteins, High Hereford x Holsteins and High Herefords. The low rebreeding performance of the High and Very High Holsteins made them uncompetitive. As indicated previously, the low rebreeding performance of Moderate Holsteins as 4-year-olds resulted in their exclusion as a breed treatment group this year.

Feedlot Performance and Carcass Merit of the Third Calves from Hereford, Hereford x Holstein and Holstein Cows

K. S. Lusby, R. D. Wyatt, D. F. Stephens and Robert Totusek

Story in Brief

Eighty-four Charolais crossbred calves from Hereford, Hereford x Holstein (Crossbred) and Holstein dams were fed from weaning (240±7 days of age) until each calf reached an anticipated grade of choice based on apparent fatness.

Holstein progeny were heavier in weight and larger in skeletal size at both weaning (entry to the feedlot) and at slaughter. Crossbred progeny were intermediate. Hereford progeny required the shortest feeding period and gained the most efficiently, followed by Crossbred progeny. Daily gains were the highest for Holstein progeny.

In cooperation with USDA, Agricultural Research Service, Southern Region.

Holstein progeny produced more carcass weight per day of age, while Hereford progeny produced carcasses with more muscling (more rib eye area/100 lb. carcass, higher conformation score). Marbling score and quality grade were highest for Holstein progeny.

Introduction

Previous research has shown that weaning weights can be greatly improved by increasing the milk production of beef cows. The fastest method of increasing milk production in beef herds is by infusing genes from dairy breeds. However, to evaluate the effect of heavier weaning weights from high milking dams on the overall efficiency of beef production, a comparison of post-weaning feedlot performance and carcass traits of beef, beef x dairy and dairy progeny is needed.

The purpose of this experiment was to compare feedlot performance and carcass traits of calves with 0, 25 and 50 percent Holstein breeding, when fed to approximately equal grade.

Experimental Procedure

The feedlot performance and carcass characteristics of calves with 0, 25 and 50 percent Holstein breeding were determined. Calves, sired by Charolais bulls, were from four-year-old Hereford, Hereford x Holstein (Crossbred) and Holstein cows calving for the third time. Dams from each breed had been wintered on one of two levels of protein supplementation, Moderate or High, while an additional group of Holsteins also received a Very High level of supplement. Daily post-calving amounts of a 30 percent natural protein supplement were 2.6, 5.8 and 8.4 lb. per day for Moderate, High and Very High supplement levels, respectively.

Calves were born in December, January and February and placed in the feedlot at weaning (240 ± 7 days of age). At weaning, all calves were shrunk for 12 hours, then weighed, photographed and vaccinated for blackleg, P13, IBR and BVD. The weaning weight was used as the initial feedlot weight. The calves were fed a 75 percent concentrate ration consisting of (percent): ground corn, 60.2; cottonseed hulls, 15.0; ground alfalfa, 10.0; cottonseed meal, 8.0; molasses, 5.0; urea 1.0; salt, 0.3; minerals and Vitamin A. Calves were group fed by sex and by dams' breed and previous level of winter supplementation.

Each calf was slaughtered when estimated to have reached a quality grade of low choice, based on apparent fatness. Final weights were taken after an overnight 12-hour shrink. All calves were slaughtered at a commercial slaughter plant and chilled 72 hours before quality grade, marbling score, maturity, conformation score and kidney, heart and pelvic fat (KHP) were estimated by a USDA grader. Ribeye area and backfat thickness were measured from a tracing at the 12-13th rib separation on each carcass. Cutability was calculated using the Murphy catability prediction equation.

Results and Discussion

Little influence of dams' previous level of winter supplementation on the calves feedlot performance or carcass traits was seen. Therefore, results for feedlot performance (Table 1) and carcass traits (Table 2) are shown only by breed of dam.

Results were similar to those reported for the previous two years. Holstein progeny were the heaviest, and Hereford progeny the lightest, at both the start of feeding and at slaughter. Crossbred progeny were intermediate. Average length of the feeding period and consequent age at slaughter increased with each increment of Holstein breeding. Holstein progeny gained slightly faster than Crossbred or Hereford progeny, while feed efficiency definitely favored Hereford progeny, followed by Crossbred progeny. Feed required per lb. of gain was 19.8 percent greater for Holstein progeny and 11.0 percent greater for Crossbred progeny than for Hereford progeny.

Carcass merit is summarized in Table 2. Carcass weight trends were similar to slaughter weights with Holstein progeny the heaviest and Hereford progeny the lightest at slaughter. Holstein progeny produced more carcass weight per day of age than Hereford or Crossbred progeny in spite of the longer feeding period for Holstein progeny. The superiority of Hereford progeny for muscling was shown by REA/100 lb. carcass weight and is consistent with previous data on these breeds. Cutability estimates also favored Hereford progeny. The higher marbling score for

Table 1. Feedlot Performance of Calves from Four-Year-Old Cows.

	Breed of Dam		
Item	Herefords	Hereford x Holstein	Holstein
No. of head	27	26	31
Initial weight, lb.[1]	548	607	667
Slaughter weight, lb.[2]	997	1091	1241
Age at slaughter, days[2]	429	450	466
Average days fed	189	210	226
Average daily gain	2.42	2.35	2.61
Feed/lb. gain, lb.	8.62	9.52	10.33

[1] Actual weaning weight.
[2] 240 days + average days fed.

Table 2. Carcass Merit of Calves from Four-Year-Old Cows.

Item	Breed of Dam		
	Hereford	Hereford x Holstein	Holstein
No. of head	27	26	31
Hot carcass weight, lb.	607	667	777
Rib eye, sq. in.	12.05	12.37	12.82
Rib eye/100 lb. carcass	1.98	1.85	1.65
Fat thickness, in.	0.73	0.75	0.75
Fat thickness/100 lb. carcass, in.	0.12	0.11	0.10
KHP Fat, %[1]	2.95	3.09	3.25
KHP Fat/100 lb. carcass, %	0.48	0.46	0.42
Cutability, %	50.0	48.5	47.8
Carcass weight/day of age, lb.	1.41	1.50	1.67
Conformation score[2]	10.6	10.9	10.1
Marbling score[3]	12.0	12.2	14.3
Carcass grade[2]	8.5	8.8	9.7

[1] Kidney, heart and pelvic.
[2] 9=high good, 10=low choice, 11=average choice.
[3] Higher score indicates more marbling.

Holstein progeny, also observed in the first calf crop, resulted in a higher carcass grade. A longer feeding period and greater age probably contributed to the greater marbling in Holstein progeny.

Economic Analysis

An economic analysis of feedlot costs and returns is presented in Table 3. The analysis is based on an average of steers and heifers for each breed. Prices used were representative of values at the time of the feeding trial. Other prices considered more appropriate may be substituted in the calculations as desired.

The following prices were used:

	Steers	Heifers
Initial value of calves (per cwt.)		
Hereford	$58.00	$52.00
Hereford x Holstein	57.00	51.00
Holstein	55.00	49.00
Value of carcasses (per cwt.)		
Choice	66.00	65.00
Good	64.00	63.00

Feed was valued at $97.50 per ton. Yardage cost was estimated at 15¢ per head per day and the interest rate was estimated at 9 percent.

The return above initial value of the calves, feed yardage and interest was calculated. On this basis, all breed treatment groups showed a loss. Hereford calves showed the smallest loss at −$151.68. Hereford x

Table 3. Economic Analysis (Average for Steers and Heifers).

Item	Breed of Dam		
	Herefords	Hereford x Holstein	Holstein
Carcass Value, $	385.45	423.55	508.28
Feedlot costs, $			
Initial value of calves	301.40	327.78	346.84
Feed cost[1]	188.68	224.62	289.06
Yardage[2]	28.35	31.50	33.90
Interest[3]	18.70	23.10	27.76
Total cost, $	537.13	607.00	697.56
Return above initial value, feed yardage and interest, $	—151.68	—183.45	—189.28
Value of carcass less cost of feed, yardage and interest, $	149.72	144.33	157.56
Value of calf for feeding, $/cwt.	27.32	23.78	23.62

[1] Total feed consumed x $97.50 per cwt.
[2] 15¢ per head per day.
[3] $[\frac{1}{2} \text{ feed cost} + \text{initial value of calf}] \times \frac{\text{days on feed}}{360} \times 0.90.$

Holstein calves were intermediate at a loss of —$183.45 and Holsteins calves showed the greatest loss at —$189.28. The lack of profitability of the feedlot phase of the project may be attributed to the high initial value of the calves combined with the high feed costs.

An additional calculation was made in which feed yardage and interest costs were subtracted from the carcass value, and the resulting return was divided by the initial calf weight. This calculation was used to provide an estimate of the value of the calves for feeding. On this basis, Hereford, Hereford x Holstein and Holstein calves had values of $27.32, $23.78 and $23.62 per cwt., respectively.

Three Levels of Nitrogen for Bermudagrass Grazed by Cows and Calves

John Gordon, Leon Knori, Mike Gould and Robert Totusek

Story in Brief

Three levels of nitrogen fertilization (65, 165 and 2 90 lb. per acre) were applied to Midland bermudagrass for three years. Increasing stocking rates were used with increasing levels of nitrogen. Calf daily gains (1.70, 1.73, 1.76 lb.day) and adjusted 240-day weaning weights (501, 492, 487 lb.) averaged over the three years indicated no significant difference in forage quality at different levels of nitrogen fertilization. The general trend observed in increasing pounds of beef per acre (233, 333, 390 lb./acre) with increasing nitrogen fertilization rates in all three years is attributed to the higher stocking rates with the higher levels of nitrogen.

Although the highest level of fertilization produced the greatest net return per acre in the first two years, the lowest level of nitrogen returned the greatest profit the third year due to changing economic conditions. Each producer should examine the current economic situation before deciding what level of nitrogen fertilization to use.

Introduction

In recent years bermudagrass has become popular as a high yielding forage for grazing cattle. It is best suited to cow-calf programs because bermudagrass is of sufficiently high quality to promote high rates of gain with stockers for only 60-90 days per year.

Nitrogen fertilization has been shown to increase forage yield significantly, but forage quality slightly in terms of crude protein content. Since forage quantity and quality are prime considerations in maximizing cattle production per unit area, the main purpose of this study was to determine the effects of three levels of nitrogen fertilization upon forage quality and quantity and their relationship to the performance of cows and calves grazing Midland bermudagrass. The effects of level of nitrogen fertilization were presented in Animal Sciences and Industry Report MP-92, 1974. This paper presents the effects of different levels of fertilization on animal performance.

In cooperation with USDA, Agricultural Research Service, Southern Region.

Materials and Methods

This study was conducted at the Fort Reno Livestock Research Station near El Reno, Oklahoma: Midland bermudagrass (Cynodon dactylon) was planted in each of 12 pastures. Each pasture was fertilized with one of three levels of nitrogen (65, 165, and 300 lb. N/acre) in split applications (May, July, and September); P_2O_5 and K_2O were applied according to soil analysis. All pastures were fertilized with liquid nitrogen in May of 1974 to enable the inclusion of 2,4-D. Urea (45 percent N) was used as the source of N for the second and third application in 1974. Ammonium nitrate was used the first two years. Pastures were graduated in size so that carrying capacity was similar for all three nitrogen levels.

Sixty Angus x Hereford cows were mated to Angus bulls for each of three years (1972, 1973, and 1974) and randomly assigned to the twelve pastures on the basis of calving date in 1972. Calf birth weights were taken within 24 hours after birth. Calves were weaned in November. Cow and calf weights were taken near the first of each month after a six hour period without feed or water.

Similar amounts of forage among pastures were maintained by varying grazing pressure with the use of "put-and-take" animals. Pastures were dragged as often as deemed necessary to prevent excessive manure buildup. Hay was cut and baled approximately every two months to control maturity. A mineral supplement composed of two parts trace mineralized salt and one part dicalcium phosphate was fed free-choice to all treatment groups.

Results and Discussion

Cow Average Daily Gain

Due to slight variation in the length of the grazing period in different years, cow daily gains rather than total weight gains were evaluated. In the first year of this study daily gains among treatments were similar because available forage was effectively equalized among treatments by the use of "put-and-take" animals. However, in the second and third years, cows on the medium level of nitrogen made the lowest gains. Therefore, the daily gains averaged over the three years showed the lowest cow gains on the medium level of nitrogen. The fact that cow gains were similar on the low and high levels of nitrogen fertilization indicates that the lower gains observed on the medium level were due to pasture differences resulting in differences in available forage, rather than level of nitrogen.

Calf Performance

Calf daily gains and weaning weights differed only slightly between levels of fertiliaztion or years. These results indicate that increasing nitro-

Table 1. Effects of Level of Nitrogen Fertilization of Midland Bermudagrass on Cow Average Daily Gain, Calf Average Daily Gain, Adjusted Weaning Weight, and Beef Production per acre.

Year	Level of Nitrogen lb. N/acre		
	65	165	290
1972			
Cow daily gain,[1] lb.	0.97[1]	0.88[1]	0.92[1]
Calf daily gain, lb.	1.67	1.75	1.68
Adjusted weaning weight,[2] lb.	477.	492.	482.
Pounds beef produced/acre, lb.	221.	332.	386.
Pounds beef produced/acre, % increase over lowest N level		50.	75.
1973			
Cow daily gain,[1] lb.	1.02[2]	0.58[1]	1.08[2]
Calf daily gain, lb.	1.74	1.73	1.72
Adjusted weaning weight.[2] lb.	501.	495.	490.
Pounds beef produced/acre, lb.	233	337	392.
Pounds beef produced/acre, % Increase over lowest N level		45.	68.
1974			
Cow daily gain,[1] lb.	0.91[2]	0.57[1]	0.68[1,2]
Calf daily gain, lb.	1.87	1.71	1.71
Adjusted weaning weight,[2] lb.	526.	489.	488.
Pounds beef produced/acre, lb.	244.	331.	392.
Pounds beef produced/acre, % increase over lowest N level		36.	61.
3-Year Average			
Cow daily gain[1], lb.	0.97[2]	0.68[1]	0.89[2]
Calf daily gain, lb.	1.70	1.73	1.76
Adjusted weaning weight,[2] lb.	501	492	487
Pounds beef produced/acre, lb.	233	333	390
Pounds beef produced/acre % increase over lowest N level		43.	67.

[1] Cow average daily gain for period May to November.
[2] 240-day weight based on daily gain from birth to weaning, average of steers and heifers.
[1-2] Means having different superscripts in the same row are significantly different ($P \leq .05$).

gen fertilization did not improve forage quality but effectually inceased forage quantity and carrying capacity. The fact that weaning wights were not markedly decreased at the higher levels of nitrogen indcates that the greater concentration of cattle at the higher levels of fertiliation did not greatly affect calf performance.

Each year there was a linear increase in the pounds of beef prducer per acre as nitrogen level increased. The three year average indicat that the medium and high levels of fertilization produced 43 and 67 prcent more beef/acre than the low level. The increased beef productio per acre was due to the higher carrying capacities at the higher levls of nitrogen fertilization, since daily gain of calves was not increased.

Economic Analysis

Changing economic conditions demand the revaluation of each producer's program each year. In the first year of this study, the advantage in net return per acre for the high level of nitrogen over the low level was approximately $41.00 (Table 2). Although nitrogen prices increased in 1973, higher priced calves produced a $47.00 advantage for the high level (Table 3). However, the economic situation changed dramatically in the third year (1974). With increasing nitrogen costs and declining calf prices the low level of nitrogen returned $16.00 more per acre than the medium level, while the high level resulted in a loss (Table 4). With present (1975) calf and nitrogen prices applied to a three year average of calf performance it is obvious that the higher levels of nitrogen would be unprofitable (Table 5).

Although in other locations with different soil types results may vary slightly, the general conclusions would probably be similar. Increasing levels of nitrogen result in increased carrying capacity and thus more beef produced per acre. However, nitrogen and calf prices may limit the feasibility of high levels of nitrogen. This study emphasized the need for each producer to revaluate his program each year.

Table 2. Effects of Level of Nitrogen Fertilization of Midland Bermudagrass on Net Return/Acre, Summer 1972.

	Level of Nitrogen lb. N/acre		
	65	165	290
Acres/cow-calf pair[1]	2.51	1.91	1.33
Cow-calf pairs/acre	0.40	0.52	0.75
Cow weight gain[2], lb.	194	176	184
Calf daily gain[3], lb.	1.67	1.75	1.68
Weaning weight[4], lb.	476	492	482
Calf/acre, lb.	190	258	362
Value of calf/acre[5], $	89.30	121.26	170.14
Fertilizer cost/acre[6], $	4.55	11.55	20.30
Return/acre above fertilizer cost, $	84.75	109.71	149.84
Net return above cow and fertilizer cost/acre, $	56.75	73.31	97.34

[1] Beginning 4-21-72.
[2] From 4-21-72 to 11-8-72.
[3] From birth to 11-8-72.
[4] 240 day weight based on daily gain from birth to 11-8-72, average of steers and heifers.
[5] Based on $47.00/cwt. for calves, average for steers and heifers.
[6] Based on $0.07/lb. of nitrogen.
[7] Based on an annual non-land fixed cow cost of $70.00/cow.

Table 3. Effects of Level of Nitrogen Fertilization of Midland Bermudagrass on Net Return/Acre, Summer 1973.

	Level of Nitrogen lb. N/acre		
	65	165	290
Acres/cow-calf pair	2.28	1.74	1.21
Cow-calf pairs/acre	0.44	0.57	0.83
Cow weight gain[1], lb.	187	107	197
Calf daily gain[2], lb.	1.75	1.73	1.72
Weaning weight[4], lb.	501	495	490
Calf/acre, lb.	220	284	405
Value of calf/acre[5], $	121.00	156.00	222.75
Fertilizer cost/acre[6], $	7.80	19.80	34.80
Return/acre above fertilizer cost, $	113.20	136.40	187.95
Net return above cow and fertilizer cost/acre[7], $	82.40	96.50	129.85

[1] Beginning 5-2-73.
[2] From 5-2-73 to 11-1-73.
[3] From 5-2-73 to 11-1-73.
[4] 240 day weight based on daily gain from birth to 11-1-73, average of steers and heifers.
[5] Based on $55.00/cwt. for calves, average for steers and heifers.
[6] Based on $0.12/lb. of nitrogen.
[7] Based on an annual non-land fixed cow cost of $70.00/cow.

Table 4. Effects of Level of Nitrogen Fertilization of Midland Bermudagrass on Net Return/Acre, Summer 1974.

	Level of Nitrogen lb. N/acre		
	65	165	290
Acres/cow-calf pair[1]	2.17	1.52	1.38
Cow-calf pairs/acre	0.46	0.66	0.72
Cow weight gain[2], lb.	172	107	130
Calf daily gain[3], lb.	1.87	1.71	1.71
Weaning weight[4], lb.	526	489	488
Calf/acre, lb.	245	331	392
Value of calf/acre[5], $	73.50	99.30	117.60
Fertilizer cost/acre[6], $	16.25	41.25	72.50
Return/acre above fertilizer cost, $	57.25	58.05	45.10
Net return above cow and fertilizer cost/acre[7], $	18.15	1.95	—16.10

[1] Beginning 4-30-74.
[2] From 4-30-74 to 11-5-74.
[3] From 4-30-74 to 11-5-74.
[4] 240 day weight based on daily gain from birth to 11-5-74, average of steers and heifers.
[5] Based on $30.00/cwt. for calves, average for steers and heifers.
[6] Based on $0.25/lb. of nitrogen.
[7] Based on an anual non-land fixed cow cost of $85.00/cow.

Table 5. Effects of Level of Nitrogen Fertilization of Midland Bermudagrass on Net Return/Acre, 3-year-Average (January, 1975 Prices Used for Economic Analysis)

	Level of Nitrogen lb. N/acre		
	65	165	290
Acres/cow-calf pair[1]	2.32	1.72	1.31
Cow-calf pairs/acre	0.43	0.54	0.76
Cow weight gain[2], lb.	184	130	170
Calf daily gain[3], lb.	1.76	1.73	1.70
Weaning weight[4], lb.	501	492	487
Calf/acre, lb.	216	286	372
Value of calf/acre[5], $	54.00	71.50	93.00
Fertilizer cost/acre[6], $	16.90	42.90	75.40
Return/acre above fertilizer cost, $	37.10	28.60	17.60
Net return above cow and fertilizer cost/acre[7], $	0.55	—20.70	—47.00

[1] Beginning 5-1.
[2] Adjusted for period 5-1 to 11-1.
[3] From birth to 11-1.
[4] 240 day weight based on daily gain from birth to 11-1, average of steers and heifers.
[5] Based on $25.00/cwt. for calves, average for steers and heifers, Oklahoma City Market prices.
[6] Based on $0.26/lb. of nitrogen.
[7] Based on an annual non-land fixed cow cost of $85.00/cow.

Feedlot

Influence of Roughage Level and Processing Method on the Digestion of High Corn Rations

N. A. Cole, R. R. Johnson and F. N. Owens

Story in Brief

The influence of roughage level and steam flaking of corn on digestion by steers was studied in 2 trials. In trial 1, the rations contained whole shelled corn with cottonseed hulls added at levels of 0, 7, 14 and 21 percent. Digestibility of dry matter, cellulose, acid detergent fiber, protein and starch all decreased as roughage level increased to 14 percent but increased slightly to 21 percent roughage to values similar to ration 7.

In trial 2, steam flaked corn with 0 or 21 percent roughage was compared with dry rolled corn with 0 or 21 percent cottonseed hulls. Digestibility of dry matter, organic matter, cellulose and protein were higher for 0 percent cottonseed hull diets than on the 21 percent roughage rations. Starch digestion was unchanged with roughage level but at both roughage levels digestibilities of all nutrients analyzed were higher with steam flaked than dry rolled corn.

Introduction

The processing of corn grain in high concentrate finishing rations has become common practice. Two of the more popularly used processing methods for corn have been steam flaked and dry rolling. When roughage levels are below 15-20 percent, whole shelled corn rations can produce equal performance to rations containing processed corn. At higher roughage levels, however, corn should be processed in same manner for optimum performance. This apparent processing method by roughage level interaction is commonly attributed to the "roughage factor" of whole shelled corn. This study was conducted in an attempt to 1) further understand the reasons for this roughage level effect on utilization of whole shelled corn, 2) to study the effects of roughage level on the utilization of steam flaked and dry rolled corn and 3) to compare these processing methods at two roughage levels.

Procedure

Trial 1:

Four hereford steers averaging 900 lbs. were housed in metabolism stalls and fed hourly by means of automatic feeders in order to obtain maximum feed intakes. Steers were fed one of the rations shown in Table 1 with rations being switched at 2 week intervals till each steer received each ration. All rations contained whole shelled corn with cottonseed hulls (CSH) supplying all the roughage in the rations. CSH levels were 0, 7, 14 and 21 percent of the rations.

Feces were collected on days 10 through 13 of each 2 week period. Feed and feces were analyzed for dry matter, cellulose, acid detergent fiber, starch and crude protein.

Trial 2:

The procedures and steers in trial 2 were the same as those used in trial 1. The rations are shown in Table 2. The rations fed were steam flaked or dry rolled corn with 0 or 21 percent cottonseed hulls.

Table 1. Dry Matter Composition of Rations in Trial 1.

Ingredient	Ration[1] 0	7	14	21
Whole shelled corn	90.0	82.0	74.0	66.0
Cottonseed hulls	--	7.0	14.0	21.0
Cottonseed meal	--	1.0	2.0	3.0
Supplement	10.0	10.0	10.0	10.0
Ground corn		1.0		
Cottonseed meal		3.2		
Urea		0.6		
Vitamins & Minerals		1.5		
Lignin source		3.6		

[1] Rations identified by level of cottonseed hulls.

Table 2. Dry Mater Composition of Rations in Trial 2.

Ingredient	Ration[2] SF-0	SF-21	DR-0	DR-21
Corn	90.0	66.0	90.0	66.0
Cottonseed hulls	--	21.0	--	21.0
Cottonseed meal	--	3.0	--	3.0
Supplement[1]	10.0	10.0	10.0	10.0

[1] Same composition as in trial 1.
[2] SF represents steamflaked corn, DR dry rolled and number refers to percentage of cottonseed hulls.

The steam flaked corn[1] was prepared by steaming corn for 20-30 minutes at 210-220°F at atmosphere pressure and then rolled to produce a product with a density of 34 lb. per bushel.

Dry rolled corn was prepared by passing the corn through rollers adjusted to crack all kernels. The density of the final product was 53 lb. per bushel.

Results and Discussion

Trial 1:

Dry matter and ADF intakes increased with increased roughage level but starch intakes remained fairly constant, (Table 3). Digestibilities of all nutrients measured decreased as roughage levels increased from 0 to 14 percent and then increased at 21 percent CSH to levels similar to the 7 percent CSH ration (Table 4). The starch digestion values suggest that

[1] Courtesy of Texas County Feedyards, Guymon, Oklahoma.

Table 3. Intakes of DM, Starch and Acid Detergent Fiber.

Nutrient	Ration[1]			
	1	2	3	4
			Trial 1	
DM[2] (lb.)	9.8	11.5	12.51	13.0
Starch (lb.)	7.1	6.9	7.0	6.2
ADF[3] (lb.)	0.6	1.3	2.0	3.0
			Trial 2	
DM[2] (lb.)	9.6	11.7	9.6	11.8
Starch (lb.)	5.4	4.6	7.0	6.3
ADF[3] (lb.)	.7	2.4	.6	2.5

[1] In trial 1 rations 1, 2, 3 and 4 are rations 0, 7, 14 and 21 respectively. In trial 2 rations 1, 2, 3 and 4 are rations SF-0 SF-21, DR-0 and DR-21 respectively.
[2] Dry matter.
[3] Acid Detergent Fiber.

Table 4. Digestibilities of DM, Cellulose, ADF, Starch and Protein in Trial 1[1].

Nutrient	Ration (% cottonseed hulls)			
	0	7	14	21
DM	84.3	78.4	71.8	74.9
Cellulose	78.2	65.7	54.1	66.0
ADF	46.2	42.0	32.9	46.7
Starch	96.4	94.7	92.2	95.4
Protein	71.4	64.0	60.5	64.4

[1] All values expressed as a percentage of total intake.

as the roughage level increased from 0 to 14 percent the rate of passage of starch through the digestive tract increased, reducing the time for digestion and lowering digestibility. The decreased DM, protein, ADF and cellulose digestion between 0 and 14 percent CSH may be due to the increase in the amount of poorly digestible CSH component. The increase noted at 21 percent CSH again suggests that rate of passage may be decreased at this roughage level.

Trial 2:

DM and ADF intakes increased when roughage levels increased but starch intakes were slightly decreased. The dry rolled corn rations had a higher starch content and thus a higher total intake. Digestibilities obtained in trial 2 are shown in Table 5. Increasing the roughage level decreased digestibility of DM, organic matter (OM), protein and cellulose by 6-10 percentage units with both corn processing methods. This decreased digestibility might be expected simply due to the poor digestibility of the DM, OM, protein and cellulose of CSH.

Steam flaked corn rations had higher digestibilities of DM, OM, starch, cellulose and protein than dry rolled corn rations at the same roughage levels. The higher digestibilities of DM and OM on the SF corn rations is a reflection of the greater availability of the starch and protein in the SF corn.

When compared to the results of trial 1, SF corn appeared to have higher digestibilities of DM, starch and protein than WSC at the same roughage levels. While WSC and DR corn appeared to have similar digestibilities. Although these effects could be due to time differences (there was approximately a 5 month period between trials) they would be expected from results of previous research.

Table 5. Digestibilities of DM, OM, Cellulose, ADF, Starch and Protein in Trial 2[1].

	Ration[2]			
Nutrient	SF-0	SF-21	DR-0	DR-21
DM	86.9	78.2	80.5	71.2
OM	88.5	79.8	82.3	72.8
Cellulose	71.6	58.1	66.1	57.6
ADF	39.6	40.3	27.1	36.8
Starch	99.5	98.9	95.7	94.1
Protein	78.2	67.2	68.2	60.5

[1] All values expressed as a percentage of total intake.
[2] SF represents steam flaked corn, DR, dry rolled, and number refers to percentage of cottonseed hulls in the diet.

Comparison of Feedlot Performance Among Various Two-Breed Cross Steers

R. R. Frahm and T. A. Stanforth

Story in Brief

Feedlot performances were compared among seven different two-breed cross steers involving a total of 142 steers. Half of the steers were placed in the feedlot at weaning and the other half grazed wheat pasture before being placed in the feedlot as yearlings. On the average, yearling fed steers were in the feedlot 32 fewer days, gained 0.15 lbs. per day more rapidly, but required 1.24 more lbs. of feed per lb. of gain than steers that were placed in the feedlot immediately after weaning. Simmental-Angus, Simmental-Hereford, Brown Swiss-Angus and Brown Swiss-Herehord steers on the average were on test 33 days longer than Angus-Hereford, Jersey-Angus and Jersey-Hereford steers and consequently were heavier at slaughter.

Feedlot ADG was similar for the Simmental crosses, Brown Swiss crosses and Hereford-Angus steers (2.76 lbs.) and were on the average 0.38 lbs. per day more rapid gaining than Jersey cross steers. Simmental-Hereford steers were most efficient (7.8 lb. of feed/lb. of gain); Simmental-Angus, Angus-Hereford and Brown Swiss-Hereford were second (8.2 lbs.); Jersey-Hereford and Brown Swiss-Angus were third (8.6 lbs.) and Jersey-Angus steers were least efficient (9.1 lbs.)

Introduction

Ample research has demonstrated that systematic crossbreeding systems can increase the pounds of calf weaned per cow in the breeding herd by at least 20 percent over straightbreeding systems. Information is needed however, as to which breeds can best be combined into systematic crossbreeding systems to maximize production efficiency under various production and management systems. An extensive research study is currently in progress to compare the lifetime productivity of various two-breed cross cows under Oklahoma range conditions when mated to bulls of a third breed. The present study compares feedlot performances of seven different crossbred steer groups under two different postweaning management regimes. Half of the steers from each group were placed in the feedlots at weaning time, whereas, the other half were grazed on

In cooperation with USDA, Agricultural Research Service, Southern Region.

wheat pasture and placed in the feedlots as yearlings. These steers were produced in the process of obtaining the various two-breed cross females to be evaluated for the main objective of the study.

Materials and Methods

Angus cows were randomly mated to Hereford, Simmental, Brown Swiss and Jersey bulls and Hereford cows were randomly mated to Angus, Simmental, Brown Swiss and Jersey bulls to produce eight different two-breed cross calves. Four bulls from each sire breed were used in these matings. The two-breed cross calves were born at the Lake Carl Blackwell Research Range west of Stillwater during February, March and early April of 1973. The calves remained with their dams on native range without creep feed until they were weaned September 25, 1973 at an average age of 205 days. Growth performance to weaning was reported by Stanforth, Frahm and Sharp, 1974, Okla. Agr. Exp. Station Misc. Pub. 92:28.

A total of 150 crossbred steers were trucked to the Ft. Reno Livestock Research Station. The oldest half of the steers in each crossbred group (a total of 78 steers) were placed in the feedlot one week after weaning. The youngest steers in each crossbred group (a total of 72 steers) were grazed on wheat pasture and placed in the feedlot on March 7, 1974 at an average age of approximately one year.

Hereford x Angus and Angus x Hereford steers were mixed and treated as a single crossbred group for the finished phase. Steers from each of the seven crossbred groups were randomly divided into two feeding pens (a total of 14 feeding pens) and were fed on self feeders the ration shown in Table 1. A total of 8 steers were removed from the feeding trial because of urinary calculi in the case of those that were placed on test at weaning time. Corn was substituted for milo from day 174 till the

Table 1. Finishing Ration for Crossbred Steers.

Ingredient	Percent in ration
Milo[1]	78
Alfalfa	8
Cottonseed Hulls	4
Molasses	5
Supplemental Pellets[2]	5
	100

[1] Corn replaced milo from day 174 through the end of the finishing period in the case of steers placed on test at weaning age because of a urinary calculi problem.
[2] Supplemental pellets consisted of 67.6% soybean oil meal (44%), 12% urea, 10% calcium carbonate, 8% salt plus aurofac, Vitamin A and trace minerals.

end of the finishing period in the weaning age group and no further urinary calculi problems occurred.

Each steer was evaluated individually and sent to slaughter at it was anticipated that he had sufficient finish to grade low choice.

Results and Discussion

Feedlot performances for steers placed on test at weaning time are presented in Table 2. Data for steers placed on test as yearlings are presented in Table 3. On the average steers that went on test as yearlings were 47 lbs. heavier in weight on test, gained 0.15 lbs. per day more in the feedlot, and were in the feedlot 32 fewer days. Average slaughter weights were similar for both test groups. Weight on test varies among crossbred groups because they were all placed on test on the same date at similar ages. Thus, differences in genetic potential for growth and differences in lactation level of dams resulted in different average weights at the start of the feeding period.

The Simmental cross steers and the Brown Swiss cross steers required the longest feeding period and thus had the heaviest slaughter weights. In the weaning group Simmental and Brown Swiss cross steers were on feed an average of 247 days and averaged 1129 lbs. at the time of slaughter. The Hereford-Angus steers and the Jersey crosses were on feed an average of 34 fewer days. Hereford-Angus steers weighed 1039 lbs. and Jersey crosses weighed 922 lbs. on the average. The same general pattern was found in the yearling test group. On the average the yearling steers were on feed 32 fewer days and the Brown Swiss and Simmental crosses were

Table 2. Feedlot Performance for Various Crossbred Steer Groups Placed on Test at Weaning Age.

Crossbred group	No. Steers	Initial Wt. (lbs.)	Final Wt. (lbs.)	Days on feed	ADG	Carcass Wt. (lbs.)	Carcass[2] grade
Angus x Hereford[1]	16	$469^{4,5}$	1039^{5}	217^{4}	$2.64^{3,4}$	634^{5}	10.7^{3}
Simmental x Angus	9	534^{3}	1180^{3}	236^{3}	2.76^{3}	723^{3}	9.9^{4}
Simmental x Hereford	10	$450^{4,5}$	1117^{3}	251^{3}	$2.68^{3,4}$	671^{4}	9.7^{4}
Brown Swiss x Angus	13	475^{4}	1116^{3}	251^{3}	$2.56^{3,4}$	679^{4}	9.7^{4}
Brown Swiss x Hereford	8	$436^{5,6}$	1104^{3}	251^{3}	$2.68^{3,4}$	676^{4}	9.9^{4}
Jersey x Angus	9	$454^{4,5}$	938^{6}	206^{4}	2.37^{4}	557^{6}	9.1^{4}
Jersey x Hereford	5	408^{6}	906^{6}	215^{4}	2.33^{4}	545^{6}	$10.0^{3,4}$
Avg. all groups	70	461	1057	232	2.57	641	9.9

[1] Includes both A x H and H x A crosses.
[2] Carcass quality grade equivalents: 11=choice, 10=choice⁻, 9=good⁺|⁻
[3,4,5,6] Means in the same column that do not have at least one superscript in common are significantly different at the 0.05 probability level.

Table 3. Feedlot Performance for Various Crossbred Steer Groups Placed on Test at Yearling Age.

Crossbred group	No. Steers	Initial Wt. (lbs.)	Final Wt. (lbs.)	Days on feed	ADG	Carcass Wt. (lbs.)	Carcass[2] Grade
Angus x Hereford[1]	16	532^{3}	1051^{5}	184^{7}	2.85^{3}	636^{4}	$9.8^{3,4,5}$
Simmental x Angus	11	532^{3}	$1120^{3,4}$	$200^{5,6}$	2.98^{3}	688^{3}	$9.9^{3,4,5}$
Simmental x Hereford	10	$515^{3,4}$	1131^{3}	$209^{4,5}$	2.97^{3}	691^{3}	$9.6^{4,5}$
Brown Swiss x Angus	12	$518^{3,4}$	$1100^{3,4}$	$217^{3,4}$	2.70^{3}	679^{3}	10.4^{3}
Brown Swiss x Hereford	10	474^{5}	$1083^{4,5}$	224^{3}	2.74^{3}	676^{3}	$10.2^{3,4}$
Jersey x Angus	7	$487^{4,5}$	914^{6}	$187^{6,7}$	2.31^{4}	533^{5}	9.4^{5}
Jersey x Hereford	6	$499^{3,4,5}$	940^{6}	179^{7}	2.47^{4}	553^{5}	9.2^{5}
Avg. all groups	72	508	1048	200	2.72	637	9.8

[1] Includes both A x H and H x A crosses.
[2] Carcass quality grade equivalents: 11=choice, 10=choice⁻, 9=good⁺.
[3,4,5,6,7] Means in the same column that do not have at least one superscript in common are significantly different at the 0.05 probability level.

about 21 lbs. lighter at slaughter than their counterparts in the weaning test group.

Average daily gain during the feeding period was very similar for the Simmental crosses, Brown Swiss crosses and Hereford-Angus steers averaging 2.66 lbs. per day in the weaning steers and 2.85 lbs. per day in the yearling steers. The Jersey cross steers gained about 0.38 lbs. per day less than the other groups.

Differences in carcass weight are primarily due to differences in slaughter weight. Dressing percent was similar among all groups over both test periods ranging from 58.2 percent to 61.8 percent.

Differences in carcass grade were not large because of the experimental design to slaughter all steers as they reached the low choice grade. In the weaning steers the desired average grade was attained only in the Angus-Hereford and Jersey-Hereford steers. The Simmental and Brown Swiss cross steers were in the very top part of the high good grade. Apparently additional time in the feedlot would be necessary to get these kinds of steers to the higher grade. The Jersey-Angus steers failed to grade low choice because of conformation, not lack of marbling. In the yearling steers, the Hereford-Angus, Simmental-Angus and Simmental-Hereford steers were apparently sent to slaughter a few days too soon. Lack of adequate conformation was the factor that prevented the Jersey cross steers from grading higher.

Feed efficiencies for each crossbred group in both test periods are presented in Table 4. Although there were some fairly large differences in feed efficiency, few of the differences among crossbred groups within a

Table 4. **Feed Efficiency for Various Crossbred Steer Groups.**

Crossbred Group	On Test at Weaning Age		On Test at Yearling Age		Avg. Both Test Periods
	No. Steers	lbs. feed / lbs. gain	No. Steers	lbs. feed / lbs. gain	
Angus x Hereford[1]	16	7.48	16	8.81^{2}	$8.14^{2,3}$
Simmental x Angus	12	7.82	11	8.47^{2}	$8.14^{2,3}$
Simmental x Hereford	10	7.26	10	8.36^{2}	7.81^{2}
Brown Swiss x Angus	13	8.09	12	$9.29^{2,3}$	$8.69^{3,4}$
Brown Swiss x Hereford	11	7.86	10	8.52^{2}	$8.19^{2,3}$
Jersey x Angus	9	8.03	7	10.24^{3}	9.13^{4}
Jersey x Hereford	7	7.78	6	$9.34^{2,3}$	$8.56^{3,4}$
Avg. all groups	78	7.76	72	9.00	8.38

[1] Includes both A x H and H x A crosses.

[2,3,4] Means in the same column that do not have at least one superscript in common are significantly different at the 0.05 probability level.

test period were statistically significant. Averaged over both test periods, Simmental-Mereford steers were the most efficient at 7.81 lbs. of feed per lb. of gain. Simmental-Angus, Angus-Hereford and Brown Swiss-Simmental-Hereford steers were the most efficient at 7.81 lbs. of feed per lb. of gain. Simmental-Angus, Angus-Hereford and Brown Swiss-Hereford were quite similar and required 0.35 more lbs. of feed per lb. of gain than Simmental-Hereford. Compared to Simmental-Hereford steers, Jersey-Hereford and Brown Swiss-Angus steers required 0.82 more lbs. feed per lb. of gain. Jersey-Angus steers were the least efficient and required 9.13 lbs. of feed per lb. of gain on the average. The Hereford cross steers were consistently slightly more efficient than their Angus cross counterparts. (Simmental-Hereford vs. Simmental-Angus, etc.)

Although the yearling fed steers were on test 32 fewer days and gained 0.15 lbs. per day more rapidly, they required 1.24 more lbs. of feed per lb. of gain than the steers started on test at weaning time.

Buffers and Subclinical Acidosis in Steers

E. C. Prigge, E. T. Clemens[1], N. A. Cole
R. R. Johnson[2] and D. Williams[3,4]

Story in Brief

To simulate subclinical acidosis, four fistulated steers in two trials were fed high moisture corn rations at 200 percent of voluntary consumption by forcing diet into the rumen through a fistula. Lactic acid levels and pH were monitored at 0, 1, 2, 4, 8, 12 and 24 hours after feeding and influence of added buffers, potassium bicarbonate, sodium bicarbonate and calcium carbonate, were studied.

All the buffers tested in trial 1 stabilized rumen pH and prevented lactic acid concentrations with potassium bicarbonate appearing to be the most effective. The calcium carbonate did limit pH depression to some extent, however delayed the return of pH in the rumen to more neutral conditions. In a second trial, potassium bicarbonate, sodium bentonite and dolomitic limestone were tested and again potassium bicarbonate limited lactic acid production and pH depression to a greater degree than any of the other buffers tested. The sodium bentonite and dolomitic limestone were also effective as buffers.

Of the compounds tested, potassium bicarbonate was most effective as a buffering agent with high moisture corn rations. However the cost of this chemical make sodium bicarbonate, sodium bentonite, dolomitic limestone and possibly calcium carbonate desirable economical alternatives.

Introduction

The use of high concentrate rations is still perhaps the most desirable method of feeding cattle to maximize gains and efficiency. However the feeding of rations with high energy densities has resulted in a series of digestive disturbances including poor food consumption, chronic rumen and liver lesions and predisposition to other diseases. Such a condition, usually brought on by over-consumption of feed, and is often called sub-clinical acidosis. Symptoms of subclinical acidosis are increased ruminal lactic acid levels and marked depression in ruminal pH.

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[4] The authors gratefully acknowledge the technical assistance of T. Watson and W. Zearfoss.

Studies from this laboratory have indicated that processing of grains increases the tendency to cause acidosis due to more rapid fermentation of grain in the rumen. If subclinical acidosis can be prevented by adding buffers to the diet, considerable economic advantage would be realized. This investigation was to examine the addition of buffers to the ration on the changes in ruminal pH and lactic acid levels.

Materials and Methods

Two trials were conducted to determine the effect of various buffers on ruminal pH and lactic acid levels. The basic rations utilized are shown in Table 1. High moisture corn was used in this study as the main concentrate ingredient. Four rumen fistulated Holstein steers were fed one of three buffers and a control ration for one sampling period, after which they were switched to another ration and this was continued until all steers were fed all rations. The buffers used in the first trial were potassium bicarbonate ($KHCO_3$), sodium bicarbonate ($NaHCO_3$) and calcium carbonate ($CaCO_3$) and in the second trial, $KHCO_3$, dolomitic limestone and sodium bentonite[5].

The rations used in both trials were fed at about 2.5 percent of body weight in 2 equal feedings. On the day previous to testing, the steers were fed one half of their half day allotment in the evening and on the sampling day the steers were offered 200 percent of their allotment for the morning feeding. If the ration was not consumed within 30 minutes, the remaining portion of the ration was placed directly into the rumen through a fistula. These procedures were used to assure comparable consumption and starting times for rumen sampling.

[5] American Colloid Company, Skokie, Illinois 60070.

Table 1. Composition of Rations Used in Trials 1 and 2.

Ingredient	Control[1]	Buffered[1] Ration
High Moisture Corn	86.8	84.8
Cottonseed hulls	8.0	8.0
Dehy Alfalfa meal	2.2	2.2
Soyban meal	2.1	2.1
Urea	0.3	0.3
Salt, trace mineralized	0.2	0.2
icalcium phosphate	0.2	0.2
$CaCO_3$	0.2	0.2
Buffer	—	2.0
Aurofac—50	225 g/ton	225 g/ton
Vitamin A (300,000 I.U./g)	200 g/ton	200 g/ton

[1] On an as is basis.

Samples of rumen fluid were taken prior to feeding on the test day and at 1, 2, 4, 8, 12 and 24 hours after feeding. No additional feed was given until the rumen sampling was completed. Lactic acid and pH were determined on the rumen samples in both trials.

When the steers were fed at regular intervals all steers usually consumed the total amount of the ration offered. However, on the day following the sampling day, the steers were frequently "off feed", especially in trial 1. The next testing period was therefore delayed until all offered feed was consumed for two consecutive days.

Results and Discussion

Trial 1. The pH depressions following 200 percent feeding can be seen in Figure 1. The pH's for all treatments were at their lowest at 8 hours after feeding, with the unbuffered diet causing the greatest depression in pH and the $KHCO_3$ being the most effective buffer with the pH about 0.3 of unit greater than the unbuffered control. The $CaCO_3$ and $NaHCO_3$ buffers showed some improvement over the controls, however, the advantage was not great. In addition the $CaCO_3$ tended to delay the return of acid condition on the rumen to more neutral (pH 7) levels following feeding. The reason for this delay is not known, however, under certain conditions it could provide lactic acid producing bacteria a more suitable environment for proliferation and this type of fermentation could possibly lead to higher incidence of acute acidosis. Lactic acid levels determined at the same time are illustrated in Figure 2.

The levels of lactic acid observed in this trial (Figure 2) were high and reached over 100 mM/liter for both the control and the $CaCO_3$ treatment. Levels in this range are frequently observed with acute acidosis. Acute acidosis was never observed in this study, however the animals were constantly "off feed" following the treatments.

Trial 2. In trial 2 the effectiveness of $KHCO_3$, dolomitic limestone and sodium bentonite as buffers were tested. $KHCO_3$ was again used as in trial 1. The rumen pH levels can be found in Figure 3. The $KHCO_3$ appeared to have the same effects as in trial 1 and was more effective than the other buffers tested. However, the cost of this chemical is high so use as a buffer in feedlot rations may not be practical.

Both the dolomitic and sodium bentonite helped control rumen pH when compared to the control ration. In addition, the pH of all the buffer treatments appeared to return to neutrality more rapidly with buffers. Again a rapid return of rumen pH to neutral levels could be as important as total extent of pH depression as a stimulating factor in subclinical acidosis due to the opportunistic nature of lactic acid producing bacteria.

These rumen lactic acid levels for trial 2 can be seen in Figure 4.

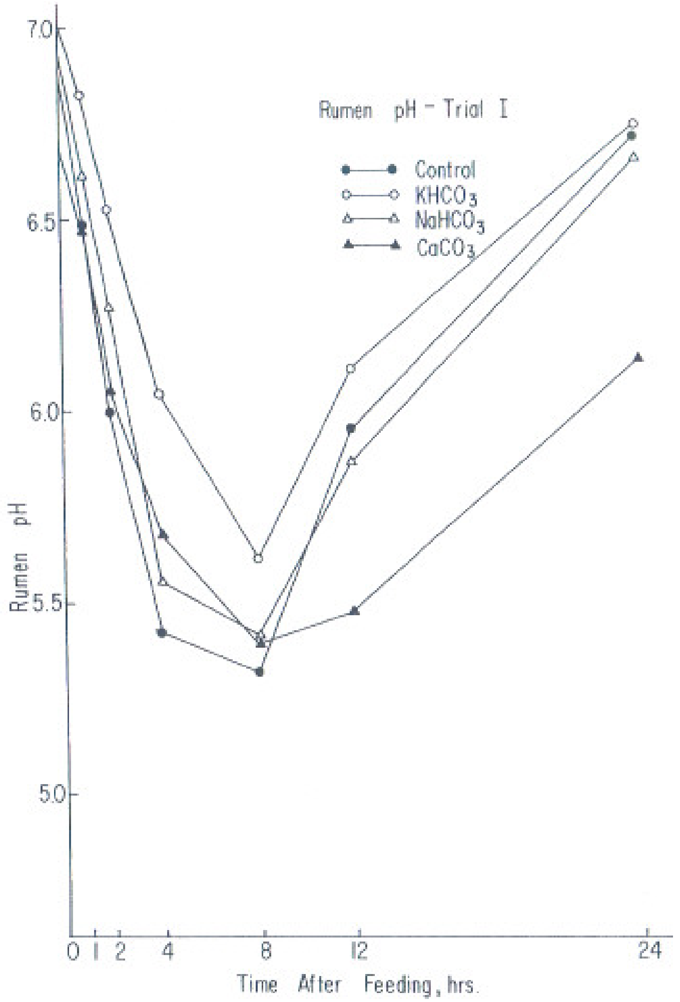

Figure 1. Changes in rumen pH after feeding rations containing either a control or $KHCO_3$, $NaHCO_3$, and $CaCO_3$ as a buffer.

The peak lactic acid level for all ration occurred at one hour after feeding with the control having the highest level and $KHCO_3$ the lowest, with the dolomite and Na bentonite levels being intermediate. It is of interest to note that the lactic acid levels in trial 2 were approximately one tenth of the levels observed in trial 1. In addition the steers in trial 2 seemed to go "off feed" less frequently than in trial 1.

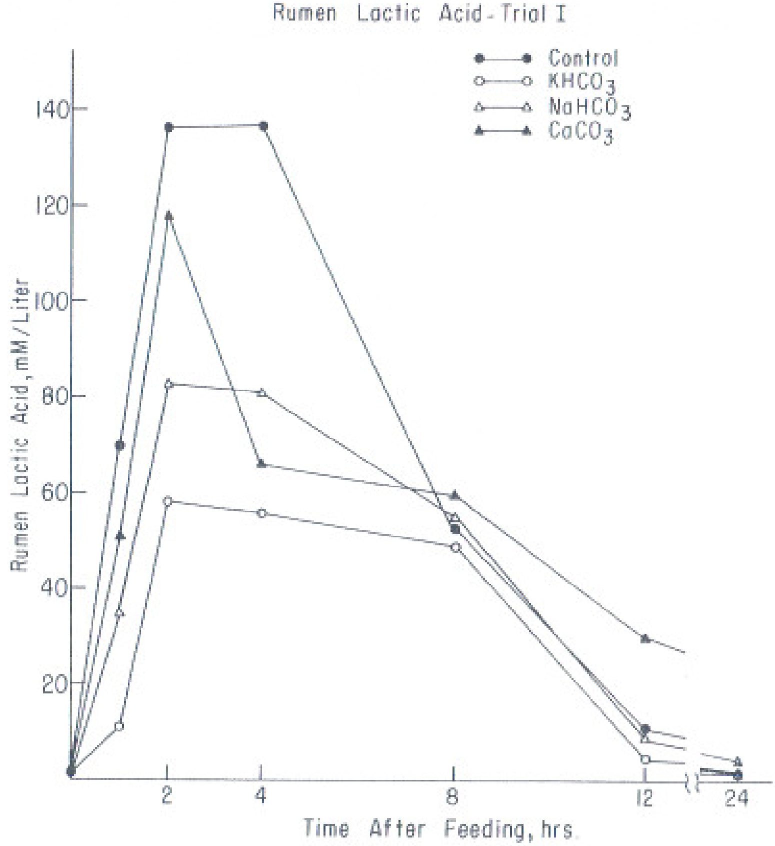

Figure 2. Changes in lactic acid levels after feeding rations containing either a control or $KHCO_3$, $NaHCO_3$ and $CaCO_3$ as a buffer.

Trial 2 was conducted one year later than in trial 1 and the high moisture corn used in trial 2 had lower levels of moisture and soluble nitrogen. Based on these observations it seems possible that the incidence of subclinical acidosis could be reduced to a greater extent by environmental factors and proper management practices during the harvesting and ensiling of high moisture corn than by the use of buffers. However since ideal management conditions and environment are not always present and buffers, such as potassium bicarbonate, sodium bicarbonate, sodium bentonite, dolomitic limestone and, possibly, calcium carbonate may aid to lower the incidences of subclinical acidosis.

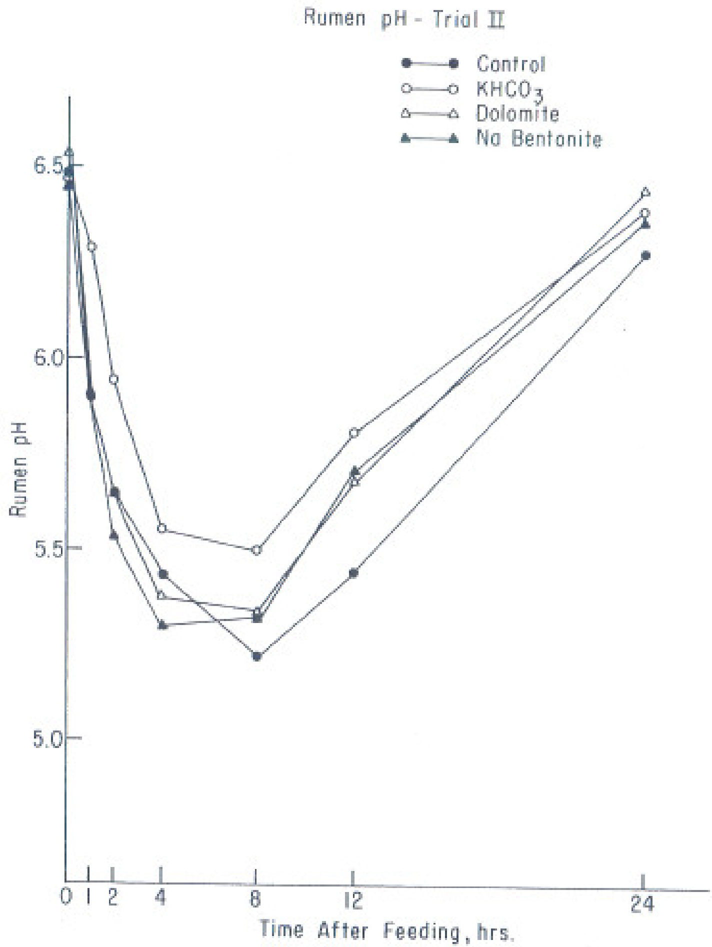

Figure 3. Changes in rumen pH after feeding rations containing a control or $KHCO_3$, dolomitic and Na bentonite as a buffer.

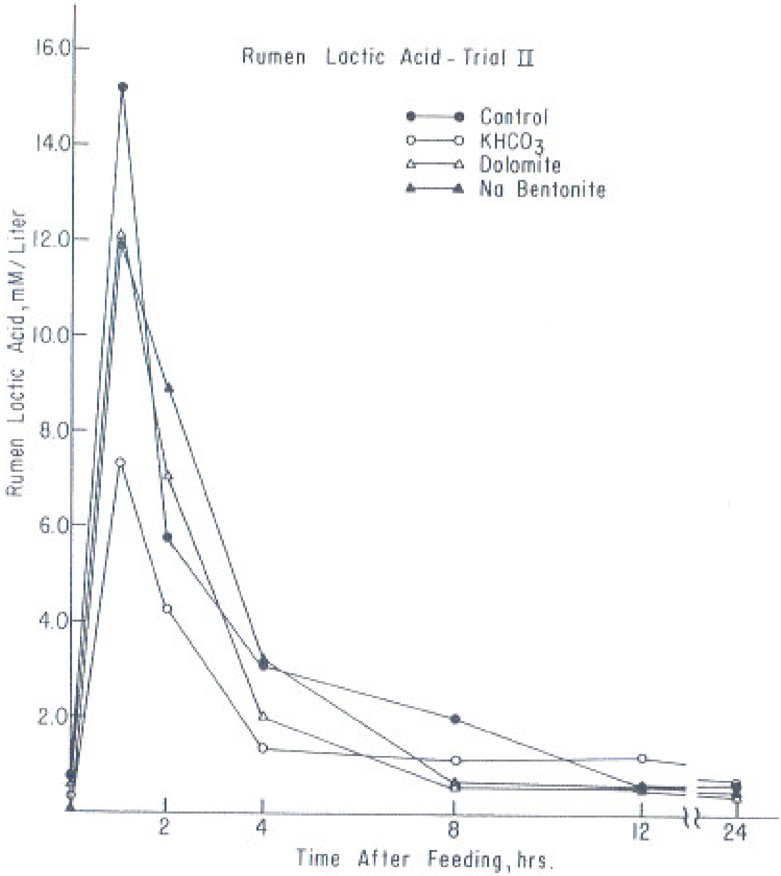

Figure 4. Changes in lactic acid levels after feeding rations containing either a control or $KHCO_3$, dolomitic and Na bentonite as a buffer.

Soluble Non-Protein Nitrogen and High Moisture Corn Utilization

E. C. Prigge, R. R. Johnson[1]
N. A. Cole and D. E. Williams[2,3]

Story in Brief

Two trials were conducted to determine the influence of high levels of soluble non-protein nitrogen in ground high moisture corn on nitrogen utilization. Four fistulated Holstein steers were fed rations containing approximately 80 percent corn in the dry or high moisture form with either soybean meal (SBM) or urea supplements. The levels of soluble non-protein nitrogen for the dry corn + SBM, dry corn + urea, high moisture + SBM and high moisture corn + urea rations were 35, 52, 73 and 92 percent of the total nitrogen, respectively. Peak rumen ammonia levels were higher ($P<.05$) with dry corn + urea ration.

Plasma urea levels were higher for steers when fed the dry corn ration than when fed the high moisture rations. Urea appeared to be utilized more efficiently with ground high moisture corn rations. A second trial was conducted in which twelve ram lambs were fed a nitrogen depletion ration for 3 weeks after which they were assigned to the rations used in trial 1. Lambs fed high moisture corn produced ($P<.05$) less urinary nitrogen and retained a greater percent of absorbed nitrogen than those fed dry corn rations. This further suggests that nitrogen in high moisture corn rations can be utilized efficiently even though it is high in soluble non-protein nitrogen.

Introduction

High moisture corn is becoming increasingly important in the feedlot industry. This method of corn storage has proven to be economical and energetically efficient when fed to ruminants. Protein of high moisture grain during storage changes from insoluble to high soluble forms and much of the protein is degraded to non-protein nitrogen (NPN). Instances of reduced feeding value of high moisture corn have been attributed to this solubilization of nitrogen.

Depressed appetites and poor gains have been observed in feedlot cattle when levels of soluble nitrogen became excessive. Cattle feeders

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are therefore reluctant to add additional NPN sources, such as urea, to high moisture corn rations, since urea would further increase soluble NPN levels and accentuate the feeding problems. In addition research suggests that use of NPN is limited in rations in which a high percentage of nitrogen is in the soluble form and proteins of low solubility are utilized less efficiently than proteins of high solubility. These observations suggest that the nitrogen of high moisture corn grain would be utilized poorly.

The objective of this study was to determine: 1) if urea can be well utilized when fed with high moisture corn and 2) if the high percentages of soluble NPN reduce efficiency of protein utilization.

Materials and Methods

The rations used in both trials of this study consisted mainly of ground high moisture corn or dry corn (Table 1). Soybean meal or urea were supplemental crude protein sources. The chemical composition of the rations are listed in Table 2. The soluble NPN content was determined in an aqueous buffer solution using sodium tungstate to precipitate the soluble protein. The solution NPN levels (Table 2) ranged from 35 percent of the total N for the dry corn (DC) + SBM ration to 92 percent for the high moisture corn (HMC) + urea ration.

Trial 1 was conducted to determine if increasing levels of soluble NPN in fermented grains would contribute to high rumen ammonia (NH_3-N) levels which might in turn limit both consumption and the ability of urea to be utilied with these rations. Rumen and blood samples were taken from four mature rumen fistulated Holstein steers fed either

Table 1. Ration Composition[1]

	Ration			
Ingredient	**DC, SBM**	**DC, Urea**	**HMC, SBM**	**HMC, Urea**
Corn	76.81	80.24	76.81	80.24
Corn Silage	15.00	15.00	15.00	15.00
Alfalfa Dehy., 17%	0.70	0.70	0.70	0.70
Soybean meal	5.75	1.72	5.75	1.72
Urea	---	0.60	---	0.60
Dicalcium Phosphate	0.20	0.20	0.20	0.20
$CaCO_3$	1.00	1.00	1.00	1.00
KCl	0.24	0.24	0.24	0.24
T. M. Salt	0.30	0.30	0.30	0.30
Aurofac-50	240 mg/kg	240 mg/kg	240 mg/kg	240 mg/kg
Vitamin A	220 mg/kg	220 mg/kg	220 mg/kg	220 mg/kg

[1] On dry matter basis.

Table 2. Chemical Composition of the Rations

Constituent	Ration			
	DC, SBM	DC, Urea	HMC, SBM	HMC, Urea
Dry Matter	73.4	73.1	61.0	61.9
ADF %[1]	8.2	7.1	8.5	7.3
Crude Protein %[1]	12.1	12.2	12.3	12.2
Soluble NPN %[2]	34.9	52.3	72.9	92.0

[1] DM basis.
[2] Percent of total nitrogen.

the DC + SBM, DC + urea, HMC + SBM or HMC + Urea rations for one sampling period. Samples were taken prior to feeding (0 hours) and at .5, 1, 2, 4, 6 and 8 hours after offering feed. Levels of ammonia, pH were determined on the rumen samples and urea in blood samples.

After the initial 10 day preliminary and 5 day sampling period the steers were switched to another ration for 15 days and again sampled twice during the last five days of this period. This was continued until all steers were sampled on all rations. On sampling days the steers were fed the assigned ration in amounts equivalent to that consumed on the dry corn+SBM ration as determined in a preliminary period. If the total ration was not consumed within 30 minutes after feeding, the remaining portion was fed through a rumen fistula. This procedure was used to assure comparable consumption and zero times for sampling.

Utilization of nitrogen for the rations used in trial 1 were determined in trial 2 using 12 western type ram lambs averaging 72 lbs. A nitrogen depletion-repletion balance trial was used. The rams were fed a depletion ration which was fairly high in energy, but contained only 2.3 percent digestible protein, for three weeks. Such depletion increases the sensitivity of the lambs to the differences in proteins. After the depletion phase, the lambs were randomly assigned to one of the four rations used in trial 1 and allowed 10 days to adapt to the ration changes. The repletion phase lasted four weeks during which samples of the ration, feces and urine were taken and nitrogen balance was determined.

Results and Discussion

The rumen pH values of the steers on the various rations (Figure 1) agree with previous observations in this laboratory with a characteristically high pH depression for high moisture corn. The levels of rumen NH_3-N (Figure 2) were not as expected. Rumen NH_3-N levels have been generally related to the solubility of the protein content of rations, but

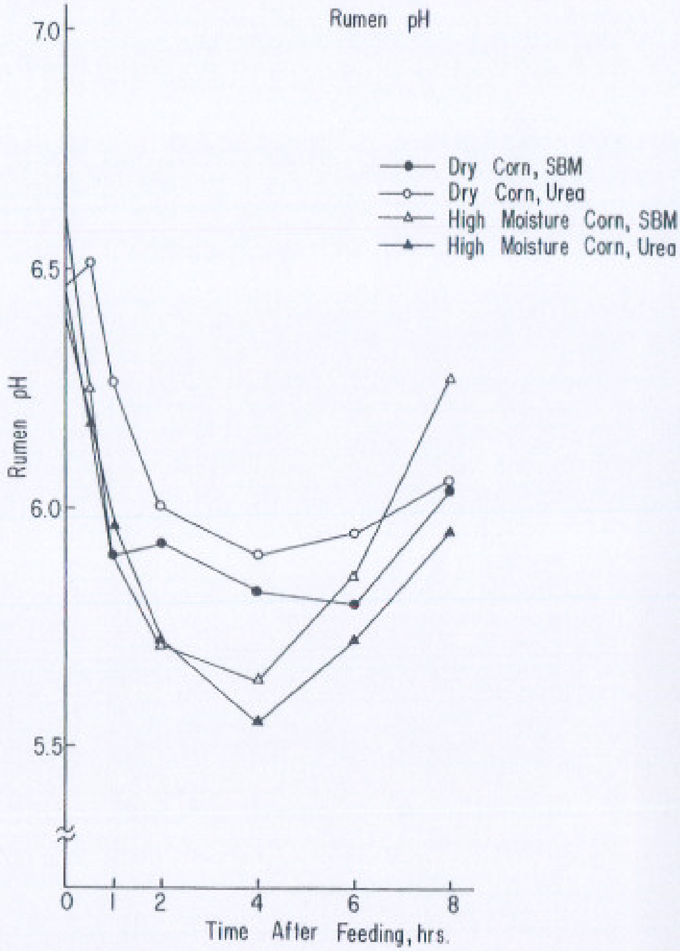

Figure 1. Rumen pH of steers fed ground dry corn supplemented with SBM or urea and ground high moisture corn supplemented with SBM or urea.

this study indicated that the dry corn + urea ration, with less soluble NPN then either of the high moisture corn rations, had greater ($P<.05$) rumen NH_3-N levels than other rations. This finding suggests that urea can be utilized efficiently in high moisture corn rations despite higher dietary levels of soluble NPN.

The plasma urea levels (Figure 3) were greater ($P<.01$) 2 hours post-feeding with the dry corn rations, suggesting greater absorption of NH_3-N

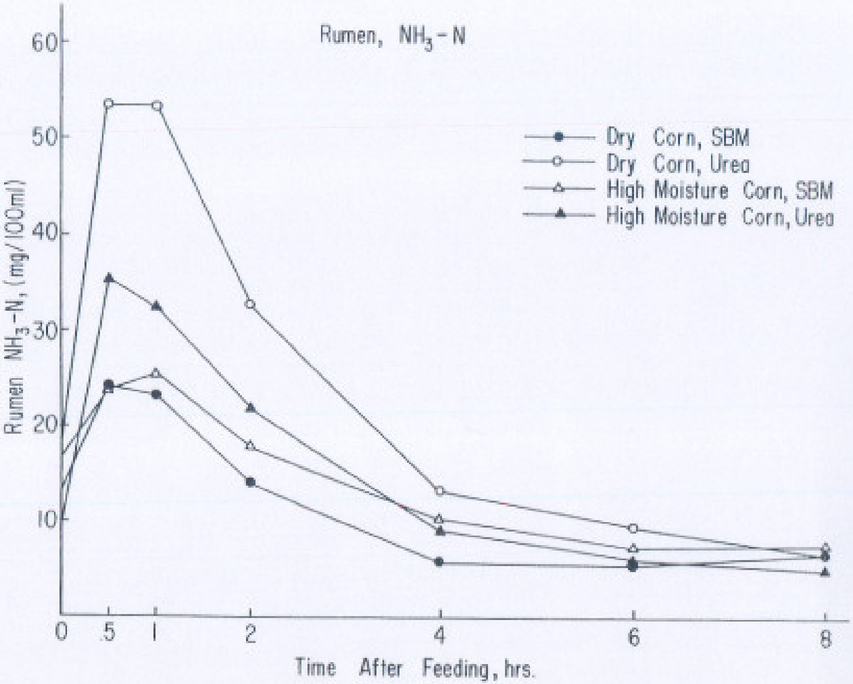

Figure 2. Rumen ammonia levels of steers fed ground dry corn supplemented with SBM or urea and ground high moisture corn supplemented with SBM or urea.

from the rumen into the blood occurred with the dry corn rations. Plasma urea level is also related to rumen pH, so higher plasma urea levels might be expected on the dry corn rations. The plasma urea levels observed for the dry corn + urea rations reflect the high rumen NH_3-N levels while the lower levels with HMC + urea rations in conjunction with the equal or lowered rumen NH_3-N levels suggest that either 1) less ammonia is formed in the rumen or 2) more ammonia is incorporated into microbial protein.

The results of the lamb repletion study are summaried in Table 3. No differences were observed in digestibility of dry matter, however protein digestibility was slightly lower for the high moisture corn rations. The urinary nitrogen was greater ($P<.05$) for the dry corn rations. Nitrogen retained as a percent of intake slightly favored ($P<.10$) the high moisture corn and the percent of the nitrogen absorbed retained was greater ($P<.05$) for the high moisture corn rations. The decrease in urinary nitrogen and increase in percent of nitrogen absorbed retained

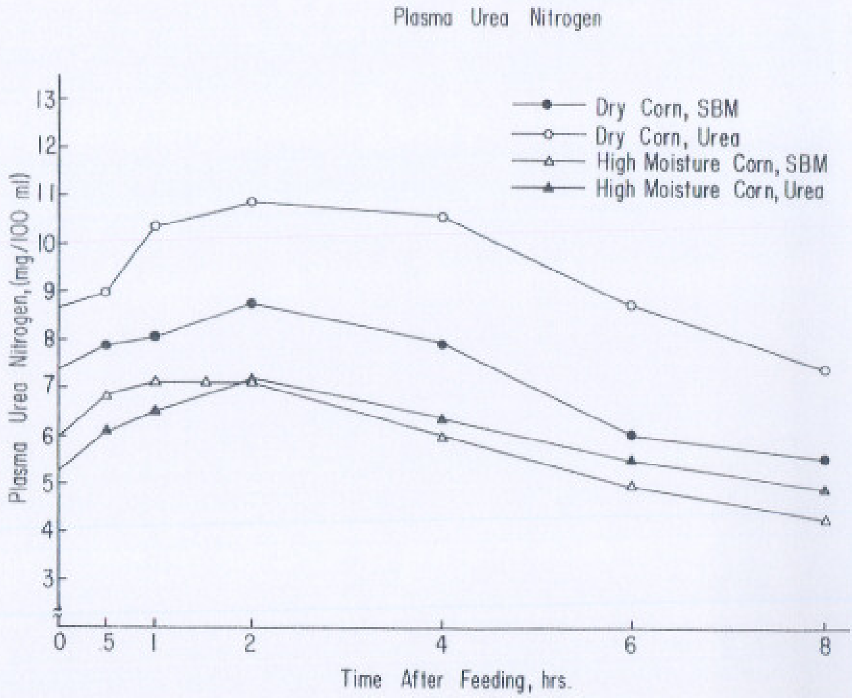

Figure 3. Plasma urea nitrogen levels of steers fed ground dry corn supplemented with SBM or urea and ground high moisture corn supplemented with SBM or urea.

Table 3. Nitrogen Depletion-Repletion Trial

Item	Ration			
	DC, SBM	DC, Urea	HMC, SBM	HMC, Urea
Digestable Dry Matter	74.2	77.3	74.4	73.5
Digestable Protein	66.5	68.7	62.5	62.4
N Intake g/day	16.6	16.4	15.4	14.1
N Retained, g/day	5.0	5.4	5.4	5.2
Fecal N, g/day	5.6	5.1	5.8	5.5
Urinary N, g/day	6.1[A]	6.8[A]	4.6[B]	4.0[B]
% N Intake Retained	30.2[a]	32.5[a]	35.0[b]	36.0[b]
% N Absorbed Retained	46.4[A]	44.0[A]	56.0[B]	59.1[B]

[A,B] Values with different superscripts differ significantly ($P < .05$).

[a,b] Values with different superscripts differ significantly ($P < .10$).

indicates that the overall protein quality of the ration was higher for high moisture corn.

In vitro gas production data in this laboratory has previously indicated that the energy from ground high moisture corn might be more readily available than that of dry corn. Thus microbial protein synthesis could occur at a great rate using more rumen NH_3-N in the process. Studies with corn silage have indicated that the soluble NPN derived from plants is degraded by rumen microbes at a slower rate than urea; therefore the soluble NPN in high moisture corn could contribute ammonia at a more efficient rate for microbial protein synthesis. Since deamination of the soluble NPN fraction would continue over a longer time, ammonia losses by absorption into the blood would be limited.

Conclusion

This study indicates that nitrogen is utilied in high moisture corn rations efficiently and that urea can as effectively supplement high moisture corn rations as dry corn rations. In addition, the results suggest that supplemental protein levels necessary for optimum performance might be lower with high moisture corn rations if bacterial protein production is increased. Further studies will determine the extent to which urea can be utilized and levels of protein required with high moisture corn rations.

Influence of Processing on the Digestion of Corn Based Rations by Steers

Mike Galyean, R.R. Johnson, and Donald G. Wagner

Story in Brief

Four mature Heredford steers were used to compare the digestion of dry rolled (DR), steam flaked (SF), propionic acid treated whole shelled high moisture (AHMC), and coarsely ground ensiled high moisture (GHMC) corn based rations.

In general, all four rations were similar in digestibility of dry matter, organic matter, crude protein, and acid detergent fiber. However, starch digestibility of SF and GHMC rations (99.14%) were higher than AHMC (95.81%) and DR (96.34%) rations. This might indicate an increased availability of energy from starch in SF and GHMC as compared with AHMC and DR rations.

Introduction

Knowledge concerning the effects of processing corn grain upon animal performance has been available for many years. Several workers have shown that feeding of heat processed (steam flaked) corn results in improvements of around 7% in feed efficiency for finishing cattle as compared to such conventional processing techniques as dry grinding and rolling. Recently, however, high moisture processing and storage of corn grain has come into extensive use, particuarly in the feedlot industry. Since little information is available concerning the digestibility of ration components of high moisture corn diets, study was undertaken to compare the digestibility of four corn rations: dry rolled (DR), steam flaked (SF), propionic acid treated whole shelled high moisture corn (AHMC), and coarsely ground ensiled high moisture corn (GHMC).

Materials and Methods

Four mature Hereford steers weighing an average of 944 pounds were housed in metabolism stalls. They were fed equal portions at two daily feedings and received the following amounts of ration dry matter (lbs) per day: DR (9.69), SF (9.87), AHMC (9.93) and GHMC (9.76). Composition of the rations is given in Table 1. Rations varied only by the method of processing.

AHMC was harvested at approximately 23 perecent moisture and treated in the whole shelled form with a commercial mixture of propionic acid (Sentry, Union Carbide Corp.) at a level of 19 lbs. preservative per ton of moist grain. The bushel weight of the final product was 49.2 lb.

Table 1. Composition of Rations

Ingredient	% in ration D.M. basis
Corn	78.0
Cottonseed hulls	15.0
Cottonseed meals	4.6
Urea	0.7
Dicalcium phosphate	0.5
Calcium carbonate	0.7
Trace mineralized salt	0.5
Vit A	150g/ton
Vit D	40g/ton
Aurofac-50	180/ton

SF was steamed at atmospheric pressure at 210-220° F for 20-23 minutes followed by rolling. The final product contained approximately 19 percent moisture with a bushel weight of 34.7 lb.

GHMC was coarsley ground through a hammermill and stored in a concrete pit silo at approximately 29 percent moisture. The moisture content of the DR grain was 88.3 percent. The particle sizes of GHMC and DR are given in Table 2.

The trial consisted of four feeding periods, each feeding period being 14 days. Each steer received a different ration in each feeding period so that by the end of the trial each ration had been fed to all four steers.

The first 10 days of each feeding period served as an adjustment period to the ration. During days 11-14 a total collection of feces was taken, weighed, and a sample was obtained for chemical analysis. The fecal samples were dried at 150° F for 48 hours and ground through a 1 mm screen in a Wiley mill. Samples of the rations also were taken each day during the fecal collection period and ground in the manner described above.

Fecal and ration samples were analyzed for dry matter, ash, organic matter, crude protein, acid detergent fiber, and starch.

Results and Discussion

Chemical composition of the rations is shown in Table 3. In general, most components were about the same for all four rations; how-

Table 2. Particle size (% retained on screen)

	Screen Size (mm)							
Grain	8	4	2	1	0.5	0.25	0.125	Pan
GHMC	0.70	13.8	39.6	30.8	12.7	1.5	0.9	----
DR	1.3	41.7	39.7	9.2	3.5	3.0	1.2	.40

Table 3. Chemical composition of rations (DM basis)

	Dry Matter	Ash	Crude Protein	Starch	Acid Detergent Fiber
	%	%	%	%	%
DR	88.19	3.56	11.66	68.92	14.94
AHMC	81.08	3.08	11.76	65.24	13.89
GHMC	74.73	3.12	11.96	75.69	13.04
SF	82.97	2.60	10.63	62.44	14.69

ever, it should be noted that the starch content of GHMC is somewhat higher than in the other rations.

Digestion coefficients for the various ration components are given in Table 4. Little difference was observed between the rations in digestibility of dry matter (DM), organic matter (OM), crude protein (CP) and acid detergent fiber (ADF). Ash digestibilities varied considerably between rations.

Perhaps the most interesting result in the difference in starch digestibilities between the four rations; starch digestibilities on SF and GHMC were higher (99.14 percent) than on AHMC and DR rations (95.81 percent and 96.34 percent respectively). This difference was judged statistically significant ($P<.05$); that is there are less than five chances in 100 that the observed difference is not real. This indicates that steam flaking and high moisture ensiling of corn grain results in increased digestion of the starch portion of the ration, possibly making more energy available to the animal. There is some evidence to indicate that this increased starch digestion observed in SF and GHMC may be due to more complete breakdown of starch in the rumen of the animal.

In brief, all four rations compare favorably in the digestion of most ration components. However, AHMC and SF corn rations may result in more available energy to the animal for productive purposes than AHMC and DR due to increased digestion of starch.

Table 4. Digestion Coefficients

	DM	OM	ASH	CP	ADF	Starch
	%	%	%	%	%	%
DR	79.90	80.89	53.94	68.38	45.61	96.34
AHMC	78.51	79.90	46.96	66.00	39.10	95.81
GHMC	80.35	81.58	42.26	66.72	36.45	99.14
SF	80.36	81.69	30.33	66.05	40.09	99.14

Micronized Wheat for Beef Cattle

Jerry Aimone and Donald G. Wagner

Story in Brief

Two methods of processing wheat in high concentrate rations for finishing beef cattle were compared. The treatments studied were: 1) dry rolled wheat (DRW) and 2) micronized wheat (MW). Two feedlot trials were conducted. In trial 1, 30 steers weighing an average of 734 pounds were fed for 112 days. Trial 2 was a 171 day feeding trial with 36 steers averaging 488 pounds.

In trial 1, average daily intakes were 20.0 and 20.6 lb. on the DRW and MW treatments, respectively. In trial 2, intakes were 15.8 and 17.2 lb. on the same treatments. Average daily gains were 3.46 and 3.65 lb. on the DRW and MW in trial 1 and 3.19 and 3.50 lb. in trial 2. The pounds of feed required per pound of gain for DW and MW were: trial 1, 5.90 and 5.69 lb.; trial 2, 4.95 and 4.92 lb. The values for daily intake and daily gain were significantly greater ($P<.01$) on MW in trial 2.

Introduction

Wheat has been used in the past and may be used in the future as a source of energy in feedlot rations. In recent years, wheat prices have been competitive at times with other grains for livestock use.

Since grain may constitute up to 90 percent of feedlot finishing rations and represents a large portion of the total cost of gain, feedlot operators should be concerned with the question of how to use grain most efficiently. Even small improvements are more meaningful than ever due to the high price of grain.

Data are limited concerning the effects of different processing methods, primarily dry heat, on the nutritive value of wheat. The purpose of this experiment, therefore, was to determine the value of micronizing wheat for feedlot cattle.

Materials and Methods

Two feedlot trials were conducted to study the effect of dry rolling wheat (DRW) or micronizing wheat (MW) in 85 percent wheat rations. In trial 1, 30 Angus x Hereford feeder steers were used. They were gradually adapted to the high wheat ration. After the two-week adaptation period they were randomly allotted to the two treatments with three animals per pen and five pens per treatment. The average initial weight of the steers was 734 lb.

Trial 2 included 36 Angus x Hereford feeder steers averaging 488 lb. Following adaptation the steers were randomly allotted to the treatments with three animals per pen and six pens per treatment. The treatments used in the two trials were: 1) DRW and 2) MW. The wheat used was of the Triumph variety, a hard winter wheat. Feed was fed once daily in an amount to allow feed to be available until the next feeding.

In trial 2, all steers were initially implanted with Synovex-S and then midway through the trial, one-half of the animals were reimplanted.

Once during each trial rumen samples were taken from each animal; pH values were taken immediately, and a small amount was saved for VFA analysis.

Initial and final shrunk weights were obtained by holding the animals off feed and water for 12 hours. At the end of the feeding trials, carcass and liver data were collected from each steer.

Results and Discussion

The ration composition for both trials is presented in Table 1. The only difference in the rations was the method of processing: the wheat being either dry rolled or micronized. The proximate analysis data are presented in Table 2. The moisture content for the MW was 8.33 percent compared to 11.33 percent for DRW in trial 1. In trial 2, the moisture content of MW was 5.27 percent compared to 10.43 percent for DRW.

The feedlot performance and carcass data are denoted in Table 3. In trial 1 (112 days), there were no significant differences ($P>.05$) between

Table 1. Ration Composition[1] (Trials 1 & 2)

Ingredient	Percent
Wheat	85.00
Cottonseed hulls	5.0
Alfalfa meal	5.0
Cottonseed meal	3.4
Urea	0.5
Salt	0.4
Dicalcium phosphate	0.4
Calcium carbonate	0.4
Total	100.0
Aurofac-50, mg/lb	123
Vitamin A supplement, mg/lb (30,000 IU/gm)	50

[1] Dry matter basis.

Table 2. Proximate Analysis

Grain	Dry Matter	Crude Protein[1,2]	Ash[1]	Ether Extract[1]	CHO[1,3]
(Trial 1)	%	%	%	%	%
DRW	89.44	14.32	2.01	1.77	81.90
MW	92.81	14.79	1.81	1.71	81.69
(Trial 2)					
DRW	89.57	14.67	2.38	1.12	81.83
MW	94.73	14.02	1.91	1.19	82.88

[1] Values expressed on 100% dry matter basis.
[2] 6.25 X percent nitrogen.
[3] 100 — (Sum of crude protein, ash and ether extract).

Table 3. Feedlot Performance and Carcass Merit

	Trial 1 (112 days)		Trial 2 (171 days)	
	DRW	MW	DRW	MW
No. steers	15	15	18	17
Initial live shrunk wt, lb.	734	730	490	485
Final live shrunk wt, lb.	1120	1138	1034	1083
Daily feed, lb.[1,5]	20.02	20.64	15.79[3]	17.22[4]
Daily gain, lb.[5]	3.46	3.64	3.20[3]	3.51[4]
Feed/lb. gain, lb.[1]	5.83	5.66	4.95	4.92
Dressing percent	61.22	61.16	61.69	62.29
Conformation[2,5]	11.87	12.07	11.50[3]	12.61[4]
Marbling[3]	11.73	12.53	12.89	13.33
Ribeye area, sq. in.[5]	12.57[1]	11.69[2]	12.23	12.78
Fat thickness, in.	.89	.89	.92	1.01
KHP fat, percent	2.57	2.73	2.50	2.61
Carcass grade	8.73	8.93	9.33	9.33
Cutability, percent[4]	48.37	47.54	48.43	47.97
Abcessed livers	5	4	12	12
Ruminal pH[5]	6.3[1]	6.5[2]	5.7[1]	6.1[2]

[1] Dry matter basis.
[2] U.S.D.A. grade converted to the following numerical designations: 7=low good, 8=average good, 9=high good, 10=low choice.
[3] Marbling scores: 11=slight, 14=small, 17=modest.
[4] Percent boneless trimmed retail cuts=52.66—5.93 (fat thickness)—0.979 (percent kidney fat)+0.665 (ribeye area)—0.008 (chilled carcass wt.).
[5] Values with different superscripts differ signifiicantly within trials:
[1,2]: ($P<.05$).
[3,4]: ($P<.01$).

treatments for any of the feedlot parameters, although average daily gain and feed efficiency tended to be better on MW. Consumption (dry matter basis) was slightly lower on DRW (20.0 *vs.* 20.6). This may be due to the finer, dustier, nature of the DRW grain. In trial 1, ribeye area was significantly less ($P<.05$) on MW.

In trial 2, average daily intake was significantly greater ($P<.01$) on MW (15.8 *vs.* 17.2 lb). Also, average daily gain was significantly greater

(P<.01) on the MW treatment (3.20 *vs.* 3.51 lb). Feed efficiency tended to be better for MW treatment, reflecting the greater feed intakes. Steers on DRW had a lower carcass conformation score (P<.01), but none of the other carcass characteristics were significantly different (P>.05) between treatments.

In both trials, the number of abcessed livers, although high, were similar between treatments. Rumen pH values in both trials were significantly higher (P<.05) on the MW.

High Moisture Barley for Beef Cattle

Jerry Aimone and Donald G. Wagner

Story in Brief

Two high moisture barley processing techniques were compared with dry rolled barley in two cattle feeding trials. In the first trial, two treatments were evaluated: 1) dry rolled barley (DRB) and 2) reconstituted barley (RB). The treatments studied in the second trial were: 1) dry rolled barley (DRB), 2) reconstituted barley (RB) and 3) high moisture harvested (HMH). Forty-eight steers averaging 675 lb. were fed for 110 days in trial 1. Trial 2 involved 36 steers averaging 623 lb. fed for 88 days.

In both trials average daily intakes were lower on the DRB treatments, with intake being significantly lower (P<.01) on DRB in trial 2. In trial 2, DRB, RB and HMH daily intakes were: 17.9, 20.6 and 20.2 lb. In both trials, steers on DRB gained slower than those on the high moisture treatments (trial 1, 3.16 *vs.* 3.24 lb.; trial 2, 2.92, 3.23 and 3.24 lb.). The feed required/lb. of gain in trial 1 was 5.64 lb. on DRB and 5.62 lb. on RB. In trial 2, the lb. feed required per lb. of gain were: 6.14, 6.40 and 6.22 on DRB, RB and HMH, respectively.

Introduction

With the current cost-price squeeze in feeding cereal grains to feedlot cattle, any benefit which can be derived in utilization is highly advantageous to the cattle feeder.

In recent years there has been quite a bit of interest in different methods of processing feed grains to gain optimum value from them. Most research has been with milo and corn. With milo, reconstitution or high moisture harvesting has been shown to be very beneficial in increasing the nutritive value of the grain.

Little work has been done to study high moisture processing of barley. The objective of this study, therefore, was to evaluate the performance of feedlot cattle fed dry rolled barley, reconstituted barley or high moisture harvested barley.

Materials and Methods

Two feeding trials were conducted to study effect of dry rolled barley (DRB), reconstituted barley (RB) or high moisture harvested barley (HMH) on the performance of feedlot cattle. The rations consisted of 84 percent processed barley on a 100 percent DM basis. In both trials the animals were gradually adapted to the rations.

In trial 1, 48 Angus, Hereford and Angus x Hereford steers were randomly allotted, 24 per treatment, to one of the two treatments, DRB or RB, and were fed for 110 days. Trial 2 was an 88 day feeding trial which involved 36 Angus, Hereford and Angus x Hereford feeder steers. They were randomly allotted, 12 steers per treatment, to one of three treatments: 1) DRB, 2) RB or 3) HMH.

Compositions of the rations fed in both trials are presented in Table 1. The only difference in the rations was the method of processing. The reconstituted barley was reconstituted in the whole form up to about 30 percent moisture. The high moisture harvested grain was harvested containing approximately 27 percent moisture. All rations were formulated to contain the composition indicated on a dry matter basis.

In trial 1, rumen samples were taken once during the trial from each animal. The pH value was determined immediately after sampling, and a small quantity was saved for VFA analysis.

Table 1. Ration Composition[1]

Ingredient	Percent
(Trial 1)	
Barley	84.0
Premix[2]	16.0
(Trial 2)	
Barley	84.0
Premix[2]	16.0

[1] Dry matter basis.
[2] Contained cottonseed hulls, ground alfalfa, cottonseed meal, urea, salt, dicalcium phosphate, calcium carbonate, aurofac-50 and vitamin A; Stilbestrol-2 was also fed in trial 2.

In both trials initial and final weights were taken as shrunk weights, the animals being off feed and water for 12 hours.

Results and Discussion

The moisture contents of the barley and the proximate analysis data are given in Table 2.

The feedlot performance data are presented in Table 3. In trial 1, there was a slight trend for increased performance on the RB ration. However, none of the feedlot characteristics measured in trial 1 were significantly different. The ruminal pH values were also the same for both treatments.

In trial 2, average daily intake (D.M. basis) on the DRB treatment was significantly lower ($P<.01$) than on either RB or HMH barley. Average daily gains and feed efficiencies were: 2.92, 6.14; 3.23, 6.40; and 3.24,

Table 2. Proximate Analysis

Grain	Dry Matter	Crude Protein[1,2]	Ash[1]	Ether Extract[1]	CHO[1,3]
(Trial 1)	%	%	%	%	%
DRB	88.50	13.95	2.99	2.04	81.02
RRB	71.23	13.14	2.75	2.05	82.06
(Trial 2)					
DRB	88.77	13.95	----[4]	----[4]	----[4]
RRB	72.27	14.89	----	----	----
HMH	72.66	14.15	----	----	----

[1] Values expressed on 100% dry matter basis.
[2] 6.25 X percent nitrogen.
[3] 100--(sum of crude protein, ash and ether extract).
[4] Incomplete data.

Table 3. Feedlot Performance

	Trial 1 (110 days)		Trial 2 (88 days)		
	DRB	RRB	DRB	RRB	HMH
No. Steers	24	24	12	12	12
Initial live shrunk wt., lb.	678	672	619	624	625
Final live shrunk wt., lb.	1025	1028	877	908	909
Daily feed, l.[1,2]	17.76	18.16	17.88[1]	20.63[2]	20.02[2]
Daily gain, lb.	3.16	3.24	2.92	3.23	3.24
Feed/lb. gain, lb.[1]	5.64	5.62	6.14	6.40	6.22
Ruminant pH	6.3	6.3	---	---	---

[1] Dry matter basis.
[2] Values with different superscripts within trial differ significantly: 1,2: ($P<.01$).

6.22 on the DRB, RB and HMH treatments, respectively.

Although the steers in trial 2 were fed for only 88 days (due to a shortage of feed) there appeared to be faster gains and greater intakes on the high moisture barley rations.

Formaldehyde Treatment of Full-Fat Soy Flour to Protect the PUFA from Rumen Microbial Hydrogenation

B. A. Ackerson, R. R. Johnson
R. L. Henrickson and F. N. Owens

Story in Brief

Ground soy flour (GSF) was treated with formaldehyde (HCHO) for *in vitro*, tissue and organoleptic studies to determine if the polyunsaturated fatty acids (PUFA) of young, growing lamb's fat tissues can be increased. Excellent protection of linoleic acid, the major PUFA in GSF, from rumen microbial hydrogenation was obtained *in vitro* when the soy flour was treated with HCHO in small quantities (100 gm) and in large quantities (20 lb).

Rump, shoulder, omental and kidney knob fat from lambs fed the HCHO treated GSF supplement had ($P<.05$) more linoleic acid than lambs fed the untreated GSF supplement. There was no difference in linoleic acid content of loin fat between lambs fed the HCHO treated GSF ration and those fed the untreated GSF ration. Lambs fed the GSF rations had ($P<.05$) more linoleic acid in their loin fat than lambs fed SBM. There were no differences ($P>.05$) in daily feed consumption, feed/kg gain or average daily gain among any of the rations. No ($P>.05$) difference in meat flavor could be detected by a taste panel among any of the treatments. In sum, acceptable polyunsaturated meat from lambs was produced.

Introduction

Recently workers in Australia and in the U.S. have produced ruminant meat and milk products high in polyunsaturated fatty acids (PUFA) by encapsulating polyunsaturated vegetable oils such as safflower or corn or soybean oil with a protein coat and then spraying this complex with formaldehyde (HCHO). This treated complex is resistant to microbial hydrogenation under the neutral conditions of the rumen, but upon entering the acid conditions of the abomasum, the complex is broken down releasing the PUFA for absorption. These unsaturated fats are absorbed from the small intestine and incorporated into the fat tissues.

Since soybeans have a natural protein-oil complex, it seemed conceivable that similar results might be achieved by soaking ground, whole soybeans (GSB) in HCHO. A previous trial was conducted in which HCHO treated and untreated GSB were fed as the supplemental protein source to young, growing lambs and no significant difference was observed in adipose tissue linoleic acid content between the two treatments. Those results may have been due to improper mixing or inadequate penetration of HCHO due to too large of a particle size. Therefore, this trial was conducted on ground, full-fat soy flour (GSF) which has a much smaller particle size. The purpose of this study was to determine by *in vitro* and animal tissue, growth and taste panel evaluation if the feeding of HCHO protected GSF to young lambs will result in increased levels of unsaturated fat in lamb fat tissue.

Methods

In Vitro Fermentations.

Approximately 100 gm samples of ground soy flour (GSF) were treated with 10.2 ml of 37 percent formaldehyde (HCHO) per 100 gm GSF along with sufficient water to cover the sample for either 2 or 6 hours. The excess water was poured off and the GSF was dried in a forced draft oven overnight. The dried soy flour was ground through a 1 mm screen in a Wiley mill and sub-samples were taken for *in vitro* incubation in a laboratory rumen fermentation by standard procedures previously used in this lab.

Soy flour was treated in 20 lb. batches with 10.2 ml of 37 percent HCHO per 100 gm GSF for 2 hrs for use in the animal study. The soy flour was dried, ground and sub-samples taken for *in vitro* incubation. Twenty ml samples were removed after various incubation times and freeze dried. The lipids were extracted, separated and measured.

Growth and Tissue Trial

Nine Western rams weighing an average of 33.5 kg were fed high concentrate finishing rations with the supplemental protein being (1) soybean meal (SBM), (2) untreated GSF or (3) GSF treated with 10.2 ml HCHO/100 gm GSF and soaked for 2 hr (10.2/2 hr). Ration compositions are shown in Table 1. The lambs were individually fed all they

Table 1. Ration Composition (Dry Matter Basis)

Ingredient	Soybean meal	Ground Soy Flour	Ground Soy Flour (10.2/2 hr)[1]
	%	%	%
Corn, ground	59.6	57.2	57.2
Soybean meal	9.2	--	--
Soy flour	--	11.5	11.5
Cottonseed hulls	29.8	29.8	29.8
Calcium carbonate	0.8	0.8	0.8
Salt	0.5	0.5	0.5
Vitamin A	+	+	+
Vitamin D	+	+	+

[1] 10.2 ml of 37% HCHO per 100 gm of soy flour, 2 hr. exposure.

could eat for 50 days. All lambs were slaughtered at approximately 100 lbs to obtain fat and tissue samples. The whole loins were removed and used for taste panel evaluation.

Taste Panel

One half of the loin was boned, the excess fat was removed, and loins from lambs receiving the same treatments composited and ground. The ground loin was baked to 160° F internally and served to a six member taste panel.

Results and Discussion

In Vitro Fermentation

Linoleic acid (18:2, 18 carbons long with 2 unsaturated positions) was markedly protected against microbial hydrogenation when GSF was treated with formaldehyde (HCHO) in small and large batches (Figure 1). Linoleic acid decreased only slightly over the 48-hr incubation period with rumen fluid when the GSF was treated with HCHO but decreased to almost 0 percent by the end of 12-24 hr. for the untreated GSF. Stearic acid, (18:0) the major end product of linoleic hydrogenation, increased only slightly over the incubation period when the GSF was treated with HCHO but showed a sharp increase in the untreated GSF samples corresponding to the sharp decline in linoleic acid. Since excellent protection of linoleic acid against ruminal activity was observed, increases in the linoleic acid content of the tissue lipids were expected.

Tissue Data

Linoleic acid (18:2) was ($P<.05$) higher (Table 2) in rump, shoulder, kidney knob and omental fat of lambs fed the HCHO treated GSF ration

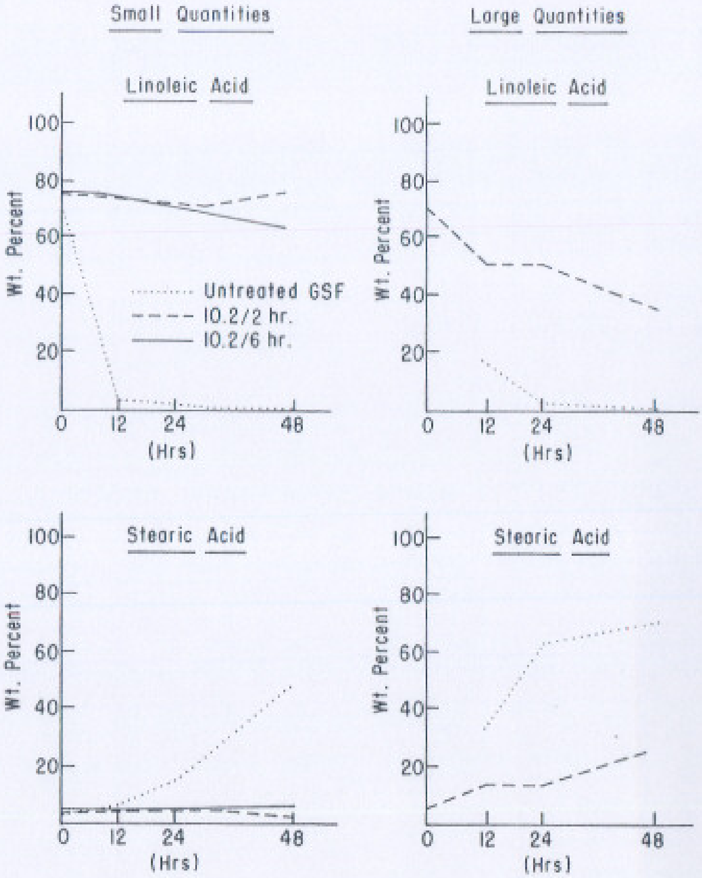

Figure 1. Weight percents of stearic and linoleic acids over a 48-hr. incubation period for untreated GSF or GSF treated with HCHO in small and large quantities.

than in lambs fed the untreated GSF ration. In addition, linoleic acid was ($P<.05$) higher in the fat tissues of lambs fed the untreated GSF ration as compared to lambs fed SBM. Myristic (14:0) and palmitic acids (16:0) were ($P<.05$) lower in the kidney fat of lambs fed the untreated GSF ration and palmitic acid was also ($P<.05$) lower in the kidney fat of lambs fed untreated GSF as compared to lambs fed SBM.

No significant differences among treatments were noted in stearic (18:0) or oleic (18:1) acids in any of the fat tissue sites. The fatty acid

Table 2. Weight Percents of the Major Fatty Acids in Selected Adipose Tissue Sites In Lambs Fed HCHO Treated and Untreated GSF

Rations[3]	14:0[1,2]	16:0	18:0	18:1	18:2
			Rump		
SBM	8.53[1]	23.44[1]	18.65[1]	40.54[1]	4.31[1]
GSF	10.96[1]	22.19[1]	19.17[1]	35.10[1]	6.82[2]
10.2/2 hr	5.91[1]	21.29[1]	19.83[1]	35.98[1]	11.86[3]
			Shoulder		
SBM	7.86[1]	25.81[1]	14.43[1]	40.83[1]	4.59[1]
GSF	6.02[1]	21.34[2]	16.20[1]	41.91[1]	9.28[2]
10.2/2 hr	5.69[1]	21.57[2]	15.28[1]	39.60[1]	11.51[3]
			Kidney		
SBM	5.92[1]	22.41[1]	30.57[1]	31.97[1]	4.94[1]
GSF	5.52[1]	20.14[2]	25.72[1]	31.93[1]	12.08[2]
10.2/2 hr	3.25[2]	17.17[3]	28.78[1]	31.57[1]	15.26[3]
			Omental		
SBM	8.84[1]	24.44[1]	23.58[1]	32.55[1]	5.96[1]
GSF	7.57[1]	20.38[2]	24.17[1]	29.56[1]	11.50[2]
10.2/2 hr	6.45[1]	18.86[2]	22.54[1]	28.76[1]	15.07[3]

[1] 14:0, Myristic; 16:0, palmitic; 18:0, stearic; 18:1, oleic 18:2, linoleic.
[2] 123: Means within columns with different superscripts differ significantly (P .05).
[3] SBM=Soybean meal; GSF=ground soy flour; 10.2/2 hr=10.2 ml HCHO per 100 gm GSF, 2 hr. exposure to HCHO.

Table 3. Weight Percents of the Major Fatty Acids In Loin Chops of Lambs on GSF Trial.

Rations	14:0[1,2]	16:0	18:0	18:1	18:2
SBM	4.88[1]	26.08[2]	14.29[1]	43.46[1]	5.65[1]
GSF	4.58[1]	23.68[1]	16.08[1]	38.61[1]	12.12[2]
10.2/2 hr.	4.11[1]	22.29[1]	15.95[1]	39.09[1]	13.56[2]

[1] See table 2 for fatty acid nomenclature.
[2] 123: Values in columns with different superscripts differ significantly ($P<.05$).

composition of loin fat (Table 3) did not differ in linoleic acid content between lambs fed the HCHO treated GSF ration and those fed the untreated GSF ration. However, the lambs fed the untreated GSF ration had ($P<.05$) more linoleic acid than lambs fed SBM. Palmitic acid was ($P<.05$) lower in the lambs fed treated and untreated GSF compared to lambs fed SBM. No differences were noted among treatments for myristic (14:0), stearic (18:0) or oleic (18:1) acids.

Growth Data

There were no significant differences among treatments for daily feed consumption, feed efficiency or average daily gain (Table 4). However, the lambs on the HCHO treated ration tended to have a poorer feed efficiency and daily gain than lambs fed untreated GSF or SBM.

Taste Panel Data

No differences in the flavor of ground loin among any of the treatment comparisons were apparent (Table 5). Cooking had no apparent effect on the fatty acid composition of the loin (Table 6).

Conclusion

With proper formaldehyde treatment and processing, the polyunsaturated fatty acids of whole fat soybeans can be protected from rumen microbial hydrogenation. This results in ruminant meat high in polyunsaturated fatty acids and which remains as desirable in flavor as meat from animals fed a conventional diet.

Table 4. Growth Performance Data on Lambs Fed Treated and Untreated Soy Flour

	Rations		
	SBM	GSF	10.2/2 hr.
No. of lambs	3	3	3
Days on trial	50	50	50
Average daily gain, lbs.[1]	.53[1]	.62[1]	.40[1]
Daily feed consumption/head, lbs.	3.04[1]	3.45[1]	3.08[1]
Feed required per lb. gain, lbs.	6.02[1]	5.65[1]	8.34[1]

[1] 1: Means within same row with same superscript do not statistically differ (P<.05).

Table 5. Taste Panel Data on Flavor of Ground Lamb

Comparison	Number of Comparisons	Number of Correct Responses[1]
SBM/GSF	24	9
SBM/2 hr	24	11
GSF/2 hr	20	10

[1] No significant differences in flavor (P>.05) among any of the comparisons.

Table 6. Fatty Acid Weight Percents of Cooked and Uncooked Ground Lamb Loins

Fatty Acids[1]	Rations[2]					
	SBM		GSF		10.2/2 hr.	
	Uncooked	*Cooked*	*Uncooked*	*Cooked*	*Uncooked*	*Cooked*
14:0	5.68	5.80	4.66	4.52	4.31	4.34
16:0	24.18	24.79	22.08	21.50	20.16	20.94
18:0	16.85	16.51	15.64	16.77	17.89	17.48
18:1	41.98	42.42	42.93	41.77	39.26	39.09
18:2	5.94	5.32	9.56	10.68	13.66	13.05

[1] See table 2 for fatty acid nomenclature.
[2] No statistical analysis was conducted as loins were composited according to rations.

Optimum Levels of Protein for Growing Boars

W. G. Luce, R. K. Johnson, S. D. Welty, B. F. Queener
and L. E. Walters

Story in Brief

A trial was conducted involving 108 growing boars to measure the effect of protein level on rate of gain, feed conversion, daily feed intake, backfat thickness, and loin eye area. The boars were fed either a 16, 18, or 20 percent crude protein ration from approximately 55 to 120 lbs. Then the protein level was reduced 2 percent for each treatment (14, 16, and 18 percent) from 120 lb. to approximately 220 lb.

The results indicate that a 16 percent crude protein ration from 55 to 120 lb. (Phase 1) and a 14 percent crude protein ration from 120 to 220 lb. (Phase 2) is inadequate for growing boars. Boars fed either a 18 or 20 percent crude protein ration during Phase 1 and a 16 or 18 percent ration during Phase 2 had a significant improvement in rate of gain, feed conversion, backfat thickness and loin eye area.

No significant differences were noted between the boars fed a 18 or 20 percent crude protein ration during Phase 1 and then decreased to a 16 or 18 percent, respectively, during Phase 2. However, the boars fed the higher levels (20-18 percent) tended to have slightly higher average daily gains.

Introduction

Oklahoma is a major state in the production of purebred breeding swine. The production of boars to sell to commercial producers or other purebred breeders is an important part of their business. Personal communication with many of these breeders reveals a certain amount of indecision on the level of crude protein to feed growing boars. The amount normally fed varies from 14 to 18 percent of the total ration. Likewise, a recent survey of boar testing stations in the United States shows that the levels of crude protein fed to growing boars also varies from 14 to 18 percent. The available literature indicates that very little research has been conducted in the area of levels of protein for growing boars. Thus, it was deemed feasible to conduct a trial to measure the effect of protein level on rate of gain, feed conversions, daily feed intake, backfat thickness and loin eye area in growing boars from approximately 55 to 220 lb. These traits measured plus soundness and conformation are the main items evaluated on growing boars by seedstock producers and swine test stations.

Experimental Procedure

One hundred and forty four Duroc, Hampshire, Yorkshire, and Duroc X Hampshire boars were used in this study. The boars averaging 55.2 pounds were randomly alloted within breed and litter to three experimental treatments. Each experimental treatment consisted of four replicates containing nine boars each. The boars were housed and group fed in an open-front concrete finishing floor equipped with self-feeders and automatic waterers.

Phase 1

Phase 1 included the period from the time the boars started test at 55.2 pounds to an average weight of 121.6 lbs. The boars on treatments 1, 2, and 3 were fed a 16, 18 and 20 percent crude protein ration, respectively. Composition of the experimental rations are shown in Table 1. At the end of Phase 1, average daily gain, feed per pound gain, and average daily feed intake was determined.

Table 1. Composition of Experimental Rations.

Ingredients %	Ration Designation			
	14% C.P.	16% C.P.	18% C.P.	20% C.P.
Yellow corn	75.00	69.50	64.00	58.30
Soybean meal (44%)	16.50	22.10	27.75	33.50
Wet Molasses	5.00	5.00	5.00	5.00
Salt	0.50	0.50	0.50	0.50
Dicalcium carbonate	1.75	1.65	1.50	1.40
Calcium carbonate	0.70	0.70	0.70	0.75
Vitamins-trace mineral mix[1]	0.50	0.05	0.05	0.05
Aureomycin 50	0.05	0.05	0.05	0.05
TOTAL	100.00	100.00	100.00	100.00
% crude protein, calculated	14.01	15.99	17.99	20.02
% calcium, calculated	0.71	0.71	0.69	0.69
% phosphorus, calculated	0.61	0.61	0.61	0.60

[1] Supplied 3,000,000 I.U. vitamin A, 300,000 I.U. vitamin D, 4 gm. riboflavin, 20 gm. pantothenic acid, 30 gm. niacin, 1,000 gm. choline chloride, 15 mg. vitamin B_{12}, 6,000 I.U. vitamin E, 20 gm menadione, 0.2 gm. iodine, 90 gm. iron, 20 gm. manganese, 10 gm. copper and 90 gm. zinc per ton of feed.

Phase 2

The boars were started on Phase 2 immediately upon completion of Phase 1. The boars on treatments 1, 2, and 3 were fed 14, 16, and 18 percent crude protein rations, respectively. This was 2 percent less crude protein then fed in Phase 1 for each treatment. Composition of the experimental rations are shown in Table 1. The boars were individually removed from test on Phase 2 when they weighed 220 lbs. Average daily gain, feed per lb. gain, average daily feed intake, and probed backfat thickness was determined. In addition, ultrasonic estimates of backfat thickness and loin eye area were obtained by the use of the Ithaco Scanogram Model 721 instrument.

The scanogram readings for estimated backfat thickness were taken at the midline at three locations (the first rib, last rib, and last lumbar vertebra). Loin eye area estimates were made at the tenth rib. All probe and scanogram estimates were adjusted to a 220 lb. basis for each boar using the National Association of Swine Records standards.

Results and Discussion

Phase 1

The results are shown in Table 2. The boars on treatment 1 (16 percent crude protein ration) had the lowest average daily gain of 1.67 lb. as compared to gains of 1.79 and 1.81 for boars on treatments of 2 and 3 respectively. Treatments 1 and 3 were significantly different ($P<.05$). Boars on treatment 1 required 2.33 lb. of feed per lb. of gain as compared to 2.18 and 2.27 for those on treatments 2 and 3 respectively. Treatment 2 was significantly lower than treatments 1 and 3 ($P<.05$). No significant differences were noted in average daily feed intake but boars on treatment 3 (20 percent crude protein) tended to consume more.

The results in Phase 1 indicates that a 16 percent crude protein ration based primarily on yellow corn and soybean meal is inadequate for growing boars from approximately 55 to 120 lbs. if optimum performance is to be obtained. The growing boars on the 18 or 20 percent crude protein ration had marked improvement in average daily gains and feed conversion as compared to those fed the 16 percent crude ration.

Phase 2

The results are shown in Table 2. The boars on treatment 1 (14 percent crude protein ration) had the lowest average daily gain of 1.81 lb. as compared to gains of 1.94 and 2.05 lb. for boars on treatments 2 and 3

Table 2. **Optimum Levels of Protein for Growing Boars.**

	Treatments		
	1 (16-14%)[1]	2 (18-16%)[1]	3 (20-18%)[1]
Pens per treatment, no.	4	4	4
Boars per pen, no.	9	9	9
Phase 1			
Av. initial wt. lb.	55.0	54.7	55.9
Av. final wt., lb.	119.5	123.4	122.0
Av. daily gain, lb.[2]	1.67^{1}	$1.79^{1\text{-}2}$	1.81^{2}
Feed per lb. gain, lb.[2]	2.33^{1}	2.18^{2}	2.27^{1}
Av. daily feed intake, lb.	3.90	3.92	4.10
Phase 2			
Av. initial wt., lb.	119.5	123.4	122.0
Av. final wt., lb.	219.5	222.8	223.6
Av. daily gains, lb.[2]	1.81^{1}	$1.94^{1\text{-}2}$	2.05^{2}
Feed per lb. gain, lb.[2]	3.24^{1}	$2.98^{1\text{-}2}$	2.90^{2}
Av. daily feed intake, lb.	5.84	5.76	5.98
Total Period			
Av. daily gain, lb.[2]	1.75^{1}	$1.87^{1\text{-}2}$	1.94^{2}
Feed per lb. gain, lb.[2]	2.88^{1}	2.65^{2}	2.66^{2}
Av. daily feed intake, lb.	5.04	4.95	5.18
Scanned backfat thickness, in.[3]	1.00^{1}	0.93^{2}	0.92^{2}
Scanned loin eye, sq. in.[3]	5.47^{1}	5.75^{2}	5.72^{2}

[1] Phase 1 treatments were a 16, 18, and 20% crude protein rations for treatments 1, 2, and 3 respectively. Phase 2 treatments were a 14, 16, and 18% crude protein ration for treatments 1, 2, and 3 resectively.
[2] Means with different superscripts are significantly different ($P \leq .05$).
[3] Means with different superscripts are significantly different ($P \leq .01$).

respectively. Treatments 1 and 3 were significantly different ($P<.05$). Boars on treatment 1 required 3.24 lb. of feed per lb. of gain as compared to 2.98 and 2.90 for those on treatments 2 and 3 respectively. Treatments 1 and 3 were significantly different ($P<.05$). No significant differences were noted in average daily feed intake but boars on treatment 3 (18 percent crude protein ration) tended to consume more.

The results in Phase 2 may have been influenced by the previous protein levels fed in Phase 1. Nevertheless, the results indicate that growing boars from approximately 120 to 220 lb. required a higher level of crude protein than 14 percent. The highest average daily gain and lowest feed conversion was obtained for the boars fed the 18 percent crude protein ration.

Total period

Performance data was computed for the total feeding period. Boars on treatment 3 (20-18 percent crude protein ration) had the highest average daily gain of 1.94 lb. as compared to 1.75 and 1.87 lb. for boars on treatments 1 and 2 respectively. Treatments 1 and 3 were significantly different ($P<.05$). Boars on treatment 1 required 2.88 pounds of feed per pound of gain which was significantly higher ($P<.05$) than the 2.65 and 2.66 lb. required by those fed treatments 2 and 3 respectively. No significant differences were noted in average daily feed intake but boars on treatment 3 tended to consume more.

Boars on treatment 1 had significantly more backfat thickness than those on treatments 2 and 3. Boars on treatment 1 also had significantly less ($P<.01$) loin eye area than those on treatments 2 and 3.

These results indicate that a 16 percent crude protein ration from approximately 55 to 120 lb. and a 14 percent crude protein ration from approximately 120 to 220 lb. is inadequate for growing boars. Boars fed the 20-18 percent crude protein rations or the 18-16 percent during the same weight periods generally had a significant improvement in rate of gain, feed conversion, backfat thickness and loin eye area. No significant differences were noted between the boars fed a 18 percent or 20 percent crude protein ration from 55 to 120 lbs. and then decreased to a 16 percent and 18 percent respectively from 120 to 220 pounds. However, the boars fed the higher levels (20-18 percent) tended to have higher average daily gains.

Feedlot Performance and Carcass Merit of Purebred and Two-Breed Cross Pigs

L. D. Young, R. K. Johnson, I. T. Omtvedt, L. E. Walters, S. D. Welty and E. Ferrell

Story in Brief

The feedlot records of 2111 barrows and gilts and the carcass records of 392 barrows representing all possible crossbreds and purebreds from crossing Duroc, Hampshire and Yorkshire breeds were analyzed to evaluate heterosis, differences among straightbreds, differences among reciprocal crosses and differences among crossbred groups.

Straightbred Durocs had the highest average daily gain, were fatter and produced carcasses that had more marbling and were firmer than Hampshires and Yorkshires. Yorkshires were the most efficient straightbred while Hampshires had the largest loin eyes and leanest carcasses followed by the Yorkshires.

Significant and favorable heterosis was found for average daily gain, age at 220 lbs., feed efficiency, feed consumption and cracass length when averaged over all crosses. The general lack of heterosis for carcass traits indicates that the carcass merit of crossbred pigs can be approximated quite well by the average of the purebreds involved in the cross.

Significant differences between reciprocal crosses did exist. When Yorkshires were involved in the cross, the pigs were more efficient, consumed less feed per day and produced carcasses that had larger loin eyes and were leaner when the Yorkshire was used as the dam than as the sire. This provides evidence that the Yorkshire female provides a more favorable maternal effect on her offspring than does the Hampshire and Duroc female.

Introduction

Although crossbreeding is used widely in this country, sufficient data on how to best combine modern breeds of swine in a crossbreeding program is not readily available. Traits such as feedlot performance and carcass merit are considered to be highly heritable therefore, they are not expected to exhibit much heterosis. However, this should not stop the commercial producer from using crossbreeding to combine the best traits of two or more breeds to produce a superior market pig.

The purpose of this paper is to provide information on the feedlot performance and carcass merit of Duroc, Hampshire and Yorkshire and their crosses.

Materials and Methods

The data for this paper includes the feedlot records of 1057 barrows (289 purebred and 768 crossbred) and 1054 gilts (306 purebred and 748 crossbred) from 362 litters (125 purebred and 237 crossbred) and the carcass records of 392 barrows (133 purebred and 259 crossbred) sampled from these litters. These pigs resulted from all possible crosses among Duroc, Hampshire and Yorkshire and were farrowed in the spring and fall of 1971 and 1973.

Five to six purebred boars of each breed were used each season and seven to fifteen litters of each breeding group were produced each season. The litters were produced by mating each boar of each breed to two gilts of each breed. All litters were produced by gilts and a new set of boars used each season.

The pigs were farrowed in confinement, moved with the sow to a nursery at about 3 days of age, given creep feed at 21 days and weaned at 42 days. Two weeks later they were moved to a confinement finishing barn and were alloted by breed group into groups of about 16 pigs per pen and were given a one week adjustment period before being weighed on test. All pigs were fed a 16 percent crude protein ration until they reached 220 lbs. Pigs were weighed off test on a weekly basis as they reached 220 lbs. and the gilts were probed for backfat at that time. Each season, a random sample of nine barrows per breed group were taken to the University Meat Laboratory for evaluation of carcass merit.

Results

Feedlot Performance

The breed group means and specific comparisons among the means for measures of growth rate, probe backfat thickness, feed consumption and feed efficiency are presented in Table 1.

Comparisons among straightbreds. Durocs gained about 0.06 lb. more per day than did Hampshires or Yorkshires and were 7.6 days younger at 220 lbs. than were the Hampshires. Durocs were also the fattest straightbred and had 0.185 and 0.144 in. more backfat than Hampshires or Yorkshires, respectively. Yorkshires were the most efficient straightbred and gained 0.013 and 0.011 more lbs. per lb. of feed consumed than did Duroc or Hampshires, respectively. However, Durocs consumed 0.46 more pounds of feed per day than did Yorkshires.

Heterosis estimates. Heterosis is the average superiority or inferiority of crossbred offspring above or below the average of purebred progeny of the breeds involved in the cross. It is calculated as the average of reciprocal crosses minus the average of the purebreds involved in the cross. The heterosis estimates for average daily gain and age at 220 lbs. were significant and in the desired direction for all crosses. Overall crossbred pigs gained 0.12 more pounds per day and were 9.9 days younger at 220 lbs. Probe backfat thickness exhibited significant heterosis only for Duroc-Hampshire crosses. Overall crossbred pigs gained 0.007 more lbs. per lb. of feed consumed than purebreds due to the positive significant heterosis for feed efficiency exhibited by Duroc-Yorkshire and Duroc-Hampshire crosses. While none of the individual heterosis estimates for feed consumption were significant, overall crossbred pigs consumed 0.17 more pounds of feed per day than did purebreds.

Comparisons among reciprocal crosses. This comparison will help provide information to decide which breed to use as a sire breed and which breed to use as a dam breed. For example, the feedlot performance of a Duroc-Yorkshire crossbred pig produced by a Yorkshire dam may not be the same as when it is produced by a Duroc dam. No significant difference existed among reciprocal crosses for average daily gain or age at 220 lbs. When Yorkshires were involved in the cross, the pigs had 0.10 in. less

Table 1. **Mean and Comparisons Among Means for Feedlot Performance and Probe Backfat Thickness.**[1]

Item[2]	No. Pigs	No. Pens	Avg. daily gain, lbs.	Age at 220 lbs., days	Probe backfat, in.[3]	lb. gain/ lb. feed	Avg. daily feed intake, lb.
$\overline{X}$	2111	142	1.587	180.72	1.170	.3149	4.879
D	183	17	1.549	184.05	1.294	.3049	5.012
H	172	16	1.487	191.66	1.109	.3071	4.734
Y	240	23	1.485	186.19	1.150	.3181	4.548
D x H	260	17	1.670	174.90	1.171	.3106	5.241
D x Y	277	15	1.653	174.93	1.149	.3298	4.722
H x D	211	11	1.632	178.62	1.148	.3216	4.983
H x Y	198	12	1.601	177.98	1.078	.3302	4.625
Y x D	290	17	1.647	175.93	1.239	.3104	5.063
Y x H	280	14	1.557	182.24	1.191	.3013	4.978
				Comparisons among straightbreds			
D - H			.062±.028*	—7.60±3.03*	.185±.033*	—.0023±.0060	.2785±.1637
D - Y			.064±.028*	—2.14±3.00	.144±.032*	—.0132±.0055*	.4641±.1497*
H - Y			.001±.028	5.47±2.95	—.041±.032	—.0110±.0056*	.1856±.1529
				Heterosis estimates[4]			
DH crosses			.133±.021*	—11.09±1.91*	—.042±.018*	.0101±.0044*	.2387±.1210
DY crosses			.133±.021*	— 9.69±1.89*	—.028±.018	.0086±.0040*	.1124±.1102
HY crosses			.093±.021*	— 8.81±1.91*	.005±.018	.0031±.0044	.1604±.1198
Overall			.120±.015*	— 9.86±1.34*	—.022±.013	.0073±.0030*	.1705±.0809*
				Comparison among reciprocal crosses			
DxH-HxD			.038±.030	— 3.72±3.14	.023±.032	—.0110±.0066	.2578±.1805*
DxY-YxD			.007±.029	— 1.00±3.04	—.090±.031*	.0194±.0060*	—.3413±.1630*
HxY-YxH			.045±.030	— 4.26±3.14	—.114±.033*	.0290±.0068*	—.3589±.1859*

[1] Backfat probe is only on gilts.
[2] D = Duroc, H = Hampshire, Y = Yorkshire.
[3] Approximately half of the pigs were gilts which were the only pigs for backfat probe.
[4] Average of reciprocal crosses minus average of purebreds involved in the cross.
*$P < .05$.

backfat, consumed about 0.35 lbs. less feed per day and gained 0.02 to 0.03 more lbs. per lb. of feed consumed when the Yorkshire was used as a dam than as a sire. Since the genetic makeup of reciprocally produced pigs is expected to be the same, any difference in performance of these pigs is probably due to a maternal effect of the dam. Thus, these data show that in crossbred litter production, Yorkshire females provide a maternal environment prior to weaning that causes their pigs to be leaner and to be more efficient and consume less feed per day in the feedlot than the same breed combination of pigs out of Hampshire or Duroc dams. Duroc dams have a similar though nonsignificant advantage over Hampshire dams.

Carcass Merit

The breed group means and specific comparisons among the means for carcass traits are presented in Table 2.

Comparison among straightbreds. There were a large number of differences among the straightbreds for carcass traits. Hampshires were the leanest of the three straightbreds and had 5.4 and 3.1 more lbs. of lean, 3.8 and 2.1 higher percent lean of the carcass and 0.17 and 0.17 in. less backfat than Durocs and Yorkshires, respectively. The fattest straightbreds were the Durocs which had 2.3 lbs. less lean and 1.7 less percent lean in the carcass than did Yorkshires. Hampshire carcasses had loin eyes that were 0.53 and 0.36 sq. in. larger than loin eyes from Duroc and Yorkshires, respectively. Duroc carcasses were 0.73 and 0.99 in. shorter than Hampshire and Yorkshire carcasses, respectively. Hampshires and Yorkshires produced carcasses with essentially equal marbling and firmness but they had significantly less marbling and softer carcasses than Durocs. The marbling score and firmness scores for Durocs were about 2.5 and 2.0 points, respectively, higher than for the other two breeds. While no significant differences existed between Durocs and Yorkshires for color score, Hampshires had color scores that averaged about 0.6 points higher than the other two breeds.

Heterosis estimates. Most carcass traits are considered to be highly heritable and therefore, the carcass traits of a crossbred should be equal to the average of the purebreds involved in the cross. When Duroc, which was the shortest straightbred, was involved in the cross, significant and positive heterosis was seen for carcass length and overall, crossbred carcasses were 0.15 in. longer than straightbred carcasses. Duroc-Yorkshire crosses had a heterosis estimate of 1.2 lbs. for pounds of lean. Duroc-Hampshire crosses exhibited positive heterosis for marbling (0.49) while Hampshire-Yorkshire crosses showed negative heterosis for color score (−.53). The lack of significant and consistent heterosis estimates for most carcass traits indicates that carcass merit of crossbred pigs can be closely approximated by the average of the purebreds involved in the cross, thus allowing the production of an overall superior carcass by combining two or more breeds.

Comparisons among reciprocal crosses. Duroc x Hampshire pigs had a 0.54 higher firmness score than Hampshire x Duroc pigs. When Yorkshires were involved in the crosses, the carcasses averaged about 3.74 more lbs. of lean, 2.7 percent more lean in the carcass, 0.12 in. less backfat and 0.43 sq. in. more loin eye area when the Yorkshire was used as the female than as the male. This suggests that the Yorkshire female provides a mat-

Table 2. Means and Comparisons Among Means for Carcass Traits.[1]

Item[2]	No. Pigs	Lean, lbs.	% Lean of carcass	Lengt, in.	B.f.t., in.	Marbling[3]	Firmness[3]	Color[3]	L.E.A., sq. in.
$\overline{X}$	392	87.11	56.72	30.55	1.211	4.26	4.79	4.83	4.731
D	43	84.38	54.77	29.88	1.264	5.83	6.16	5.24	4.480
H	46	89.77	58.56	30.61	1.093	3.25	3.78	4.52	5.012
Y	44	86.69	56.51	30.87	1.260	3.40	4.28	5.08	4.650
D x H	45	87.20	56.70	30.50	1.187	5.27	5.56	4.98	4.761
D x Y	41	88.38	57.44	30.57	1.219	5.15	5.50	5.15	4.857
H x D	42	87.65	57.06	30.53	1.165	4.79	5.02	4.83	4.775
H x Y	41	89.52	58.68	30.80	1.126	3.16	3.93	4.46	5.021
Y x D	44	85.07	55.18	30.64	1.304	4.66	5.27	5.12	4.511
Y x H	46	85.35	55.58	30.57	1.282	2.83	3.57	4.07	4.510
					Comparisons among straightbreds				
D - H		—5.39±.78*	—3.78±.49*	—.73±.14*	.171±.029*	2.58±.28*	2.38±.27*	.72±.20*	—.532±.106*
D - Y		—2.31±.78*	—1.73±.49*	—.99±.14*	.004±.030	2.43±.28*	1.87±.27*	.16±.21	—.170±.108
H - Y		3.08±.77*	2.05±.48*	—.25±.14	—.167±.029*	—.15±.27	—.50±.27	—.56±.20	.361±.106*
					Heterosis estimates[4]				
DH crosses		.35±.56	.21±.35	.27±.10*	—.003±.021	.49±.20*	.32±.19	.03±.15	.022±.076
DY crosses		1.19±.56*	.67±.35	.24±.10*	—.001±.021	.29±.20	.17±.19	—.02±.15	.119±.077
HY crosses		—.80±.55	—.40±.34	—.05±.10	.028±.021	—.33±.20	—.28±.19	—.53±.14*	—.066±.076
Overall		.25±.39	.16±.24	.15±.07*	.008±.015	.15±.14	.07±.14	—.18±.10	.025±.054
					Comparison among reciprocal crosses				
D x H - H x D		—.44±.79	—.36±.49	—.03±.14	.022±.030	.48±.28	.54±.27*	.15±.21	—.014±.108
D x Y - Y x D		3.31±.79*	2.26±.50*	—.07±.15	—.085±.030*	.50±.28	.23±.27	.03±.21	.346±.109*
H x Y - Y x H		4.17±.79*	3.10±.49*	.23±.14	—.156±.030*	.33±.28	.36±.29	.40±.21	.511±.108*

*P < .05.
[1] Carcass data on barrows only.
[2] D = Duroc, H = Hampshire, Y = Yorkshire.
[3] Score of 1 is devoid of marbling, pale and very soft; score of 7 is abundant marbling, dark and very firm.
[4] Average of reciprocal crosses minus average of purebreds involved in the cross.

ernal environment prior to weaning that not only affects feedlot performances but also causes their pigs to be leaner and more heavily muscled than the same breed combination out of Duroc or Hampshire dams.

Summary. The heritabilities for feedlot performance and carcass traits are moderate to high, thus the comparisons among straightbreds suggests that on the average Duroc sires should produce pigs that gain faster and produce firmer and more marbled carcasses than pigs out of Hampshire or Yorkshire sires when all are bred to the same breed of dam. Similarily, Hampshire sires should on the average produce pigs that have carcasses that have a higher percent lean, less backfat and larger loin eyes than Yorkshire or Duroc sires.

The differences in reciprocal crosses indicate that if Yorkshires are to be used in the cross, they should be used as the dam breed. Crosses involving the Yorkshire are more efficient in the feedlot and produce carcasses that are leaner and more heavily muscled when the Yorkshire is used as the dam than as the sire.

The data indicate that significant heterosis can be expected for average daily gain, age at 220 lbs., feed efficiency, average daily feed consumption and carcass length and very little heterosis is to be expected for most carcass traits.

Trends in Performance of Boars in the Oklahoma Swine Test Station

R. K. Johnson and W. G. Luce

Story in Brief

The performance records of 385 boars of seven breeds that completed the tests conducted by the Oklahoma Swine Evaluation Station have been analyzed to determine the average changes in performance over time for the tests conducted from 1971 spring to 1974 spring. The traits measured were individual average daily gain and pen feed efficiency from 70 to 220 lbs., backfat thickness and loin eye area at 220 lbs. and a performance index composed of a combination of gain, feed efficiency and backfat.

Very few significant changes have occurred in the average performance for boars of each breed. In general, most changes in average performance for boars of each breed have been in the desired direction. Most breeds have shown a steady increase since the first test in growth rate and a corresponding reduction in the pounds of feed required per pound of gain. Backfat changes over time have been small and not consistently in the desired direction for all breeds. Loin eye area has shown a steady increase over time for nearly all breeds, even though test station standards place little emphasis on loin eye area. Because of the general improvement in gain and feed efficiency, average index values have steadily increased for most breeds.

Introduction

The popularity of swine testing as a means of improving the swine population has greatly increased during the past few years. Testing represents an effort to increase accuracy in selecting for traits that can be measured by testing procedures. The present Oklahoma Swine Test Station was built in 1970 and testing was started in 1971. The Station is intended to secure performance records through which superior individuals and strains may be identified and through which the individual breeder may evaluate the performance of his stock. In this way, the Station provides a pool of tested stock for both purebred and commercial breeders and will assist in the improvement of the performance and quality of Oklahoma market hogs.

The purpose of this report is to describe the change in performance of boars of each breed in the first seven tests of the Oklahoma Swine Test Station.

Materials and Methods

The Oklahoma Swine Evaluation Station was built in 1970 and the first test was conducted in 1971 spring. The station has 24 5 ft. x 15 ft. open front pens with 10 ft. of alumnium slats.

There have been some minor changes in testing procedure since the first test. In general, a swine breeder's entry consisted of a pen of three boars and one barrow or two boars and two barrows. These four pigs were the progeny of one sire. The pigs that made up the spring test in each year were farrowed in February and the fall test pigs were farrowed in August. The pens averaged weighing between 35 and 70 lbs. and were under 80 days of age when delivered to the test station. They were at the test station at least five days before going on test. Those pens not averaging 70 lbs. at the end of the pretest period were put on test at a later date when the pen averaged 70 pounds. An 18 percent crude protein, ¼ inch pelleted ration was fed until the pen averaged 100 lbs. in weight at which time they were switched to a 16 percent crude protein ration.

Data collected on the boars at the swine evaluation station and the Oklahoma State University Live Animal Evaluation Center when they reached 220 lbs. included rate of gain, pen feed efficiency and a scanogram estimate for loin eye area and backfat thickness. Pen feed efficiency was adjusted to a boar equivalent by assuming that boars required 0.27 pounds less feed per pound of gain than barrows. The backfat measurements were taken approximately 1.5 in. each side of the midline behind the shoulder, at the last rib and at the last lumbar vertebrae. The scanogram estimate of loin eye was taken at approximately the 10th rib. Average backfat thickness and loin eye area were adjusted to a 220 lb. basis with adjustment factors approved by the National Association of Swine Records.

Results and Discussion

The records in these analyses include the 385 boars that completed the seven tests from 1971 spring through 1974 spring. The number of boars of each breed completing each test is shown in Table 1. Beginning with the 1972 fall test, breeders were allowed to test a pen consisting of either two boars and two barrows or three boars and one barrow. This accounts for the increased number of boars in the latter tests.

The average daily gain and feed efficiency for boars of each breed and each test are presented in Table 2. The boars in each pen started on test at an average weight of 70 lbs. and were weighed off test weekly as they weighed 220 lbs.

The overall year and season of test averages presented in the bottom of each of the tables are the averages only for the Duroc, Hampshire and

Table 1. Number of Boars of Each Breed Completing Each Test.

	Year and Season of Test							
Breed	1971S	1971F	1972S	1972F	1973S	1973F	1974S	Total
Berkshire	2	7					3	12
Chester White	6		2	6	3	8	11	36
Duroc	14	16	16	18	24	18	24	130
Hampshire	16	12	14	15	17	15	5	94
Poland	6	5	4					15
Spot			2	7	12	11	12	44
Yorkshire	4	2	8	9	5	15	11	54
Total	48	42	46	55	61	67	66	385

Yorkshire breeds that were represented in each test. From these tables, an estimate can be made of the phenotypic trends that have been occurring since the first test.

There has been a general increase in growth rate over time and a corresponding decrease in the amount of feed required per pound of gain. Some of the improvement in feed efficiency may be attributed directly to two management changes. Between the 1971 fall and the 1972 spring tests new feeders were installed that greatly reduced the amount of feed wastage and in the 1974 spring test, the feeder hole of each feeder was cleaned daily and uneaten feed was weighed back. These changes appear to have reduced feed wastage and resulted in considerable improvement in feed efficiency.

The average backfat thickness and loin eye area for boars of each breed are presented in Table 3. There appears to be relatively little change in backfat thickness over time; however average loin eye area seems to have increased slightly.

The average performance for individual boar index is shown in Table 4. There has been a marked increase in the index since the first test due in part to the increase in growth rate but due primarily to improved feed efficiency.

To better estimate the phenotypic time trends that have occurred since the first test, the breed means for each test were regressed on test number to estimate the average change in performance per test for each trait. These regression coefficients are presented in Table 5.

Average daily gain on test has increased with each test for all breeds except the Polands who had a slight decline in average growth rate for the three tests in which they were represented. Significant average increases per test in growth rate were found only for Berkshires and Chester Whites.

There were no significant changes in average backfat thickness for any breed and the breeds were not consistent in the direction of change in backfat thickness. Chester White and Duroc breeds have had virtually no change in average backfat thickness since the first test. Berkshire, Hampshire and Spot breeds have tended to increase in average backfat while the Poland and Yorkshire breeds have decreased somewhat in average fat thickness.

All breeds, except the Spot breed, have shown a favorable average improvement per test in feed efficiency. The Duroc and Hampshire breeds have had a significant average change per test of –.05 and –.06 lbs. of feed per lb. of gain, respectively.

All breeds, except the Spots, have had an average increase per test in loin-eye area; however, only the increase of 0.064 sq. in. per test in loin eye area for Hampshires was significant.

Table 2. Average Daily Gain and Feed Efficiency for Boars of Each Breed and Each Test.

Breed	Year and Season of Test[1]															
	1971S		1971F		1972S		1972F		1973S		1973F		1974S		Overall Avg.	
	ADG	FE	ADG	FE	ADG	FE	ADG	FE	ADG	FE	ADG	FE	ADG	FE	ADG	FE
Berkshire	1.91	2.86	1.80	3.04									2.06	2.45	1.92	2.78
Chester White	1.56	2.85			1.73	2.78	1.84	2.67	1.89	2.67	1.90	2.80	1.90	2.50	1.81	2.71
Duroc	2.00	2.84	2.02	2.73	1.95	2.52	1.98	2.56	1.94	2.56	2.03	2.58	2.07	2.50	2.00	2.61
Hampshire	1.79	2.87	2.02	2.76	1.86	2.65	1.99	2.60	1.82	2.71	1.97	2.58	1.99	2.41	1.92	2.65
Poland	1.80	3.09	1.78	3.10	1.77	2.58									1.78	2.92
Spot					1.91	2.59	1.95	2.84	1.93	2.57	2.00	2.96	1.98	2.55	1.95	2.70
Yorkshire	1.82	2.85	1.27	3.01	2.05	2.62	2.03	2.44	1.88	2.72	2.01	2.58	1.99	2.62	1.93	2.69
Overall Avg.[2]	1.87	2.85	1.92	2.83	1.95	2.60	2.00	2.53	1.88	2.66	2.01	2.58	2.02	2.50		

[1] 1971S = 1971 spring test and 1971F = 1971 fall test, etc.
[2] Overall season averages based only on Duroc, Hampshire, and Yorkshire breeds that were represented in every test.

Table 3. Average Backfat Thickness and Loin Eye Area for Boars of Each Breed and Each Test.

Breed	Year and Season of Test[1]															
	1971S		1971F		1972S		1972F		1973S		1973F		1974S		Overall Avg.	
	BF	LEA	BF	LEA	BF	LEA	BF	LEA	BF	LEA	BF	LEA	BF	LEA	BF	LEA
Berkshire	0.88	5.38	1.03	5.86									0.99	6.06	0.97	5.77
ChesterWhite	1.03	5.13			0.99	5.60	0.90	5.57	1.10	5.98	0.99	5.97	0.97	5.54	1.00	5.63
Duroc	1.01	5.30	1.01	5.61	0.97	5.50	0.92	5.41	0.99	5.82	0.98	6.06	1.03	5.62	0.99	5.62
Hampshire	0.77	5.95	0.91	5.85	0.87	5.77	0.79	5.84	0.86	6.16	0.87	6.13	0.91	6.23	0.85	5.99
Poland	1.05	5.45	0.93	5.96	0.86	5.66									0.94	5.69
Spot					0.81	5.96	0.87	5.71	0.95	6.05	0.95	5.99	0.94	5.30	0.90	5.80
Yorkshire	1.15	5.07	1.17	5.71	0.98	5.50	0.90	5.50	1.02	5.61	0.96	5.99	0.95	5.28	1.02	5.52
Overall Avg.[2]	0.98	5.44	1.03	5.72	0.94	5.59	0.87	5.58	0.95	5.86	0.94	6.06	0.96	5.71		

[1] 1971S = 1971 spring test and 1971F = 1971 fall test, etc.
[2] Overall season averages based only on Duroc, Hampshire, and Yorkshire breeds that were represented in every test.

Table 4. Average Index[1] for Boars of Each Breed and for Each Test.

Breed	Year and Season of Test[3] 1971S	1971F	1972S	1972F	1973S	1973F	1974S	Overall Avg.
Berkshire	185.2	160.5					207.2	184.3
Chester White	149.4		169.0	185.8	177.9	180.3	193.9	176.1
Duroc	186.4	191.9	197.1	200.4	193.6	200.5	205.4	196.5
Hampshire	181.1	196.8	191.3	207.9	185.6	202.6	208.2	196.2
Poland	157.2	162.9	186.5					168.9
Spot			201.0	190.1	194.3	184.4	200 2	194.0
Yorkshire	162.2	146.6	200.5	211.2	180.8	200.9	197.5	185.7
Overall Avg.[2]	176.6	178.4	196.3	206.5	186.7	201.3	203.7	

[1] Individual boar index = 200 + 80 (ADG) − 60 (BF probe) − 40 (FE)
[2] Overall season averages based only on Duroc, Hampshire and Yorkshire breeds that were represented in every test.
[3] 1971S = 1971 Spring test and 1971F = 1971 Fall test, etc.

Table 5. Average Change in Performance Per Test for Boars of Each Breed.

	Trait: Avg. daily gain, lbs.	Backfat thickness, in.	lbs. of feed/lb. gain	Loin eye area, in.[2]	Index
Berkshire	.041*	.009	—.084	.090	5.50
Chester White	.059**	—.003	—.042	.098	6.47*
Duroc	.008	.001	—.050*	.078	2.53*
Hampshire	.017	.012	—.060**	.064*	3.11
Poland	—.016	—.093	—.255	.105	14.65
Spot	.018	.034	.004	—.104	—.80
Yorkshire	.033	—.036	—.052	.046	7.04
Overall Avg.	.017	—.008	—.053*	.063	4.20

* Average change per test is significantly different from zero, P ≤ .05.
**Average change per test is significantly different from zero, P ≤ .01.

The Spot breed was also the only breed that has not had an average increase per test in index score. Spots have had virtually no change in average index since the first test. Only the Duroc and Chester White breeds have had a significant increase.

When only the three breeds that have been represented in every test are considered, there has been a favorable change per test in each trait measured; however, the only significant change has been for feed efficiency.

The changes observed over time at the test station may be due to several factors. Improved average genetic merit of the pigs on test is only one factor that can contribute to this change. In addition, factors associated with improved management will improve performance over time and can not be separated from the genetic differences between pigs of different tests. In addition, differences in performance of pigs of the different breeds do not necessarily reflect breed differences. The relatively small number of animals in some breeds, Polands and Berkshires, for example, leave room for a very large amount of sampling error in these breeds. Also, most pigs that enter the test station are carefully selected and differences in the ability of breeders to select pigs for testing is part of the bias that may exist in breed comparisons of these data. Breeders also learn from past experience and this may be reflected in the average improvement over time for the traits measured.

These data do document the average performance of pigs at the test station and do show a general improvement. Hopefully, most of the improvement is due to improved average genetic merit of the pigs entered into each test. This in turn should result in improved performance of the breeders herd and of herds which purchase breeding stock from breeders who are testing boars. In this way, the Oklahoma Swine Test Station appears to be making an important contribution to improving total efficiency of swine production in Oklahoma.

Performance of Pigs Fed Least Cost Computer Rations

W. G. Luce and C. V. Maxwell

Story in Brief

A trial was conducted to study the performance of pigs fed least cost computer rations as compared to a grain sorghum-soybean meal control ration. Treatments involved were (1) a basal grain sorghum-soybean meal ration (2) a least cost computer ration fed throughout the trial and (3) a least cost computer ration reformulated every 29 days using current prices of the feed ingredients available.

Pigs on treatment 1 (the grain sorghum-soybean meal control ration) tended to have higher daily gains, require less feed per pound of gain, and have a higher average daily feed intake. The generally decreased per-

formance of the pigs on the least cost computer rations (treatments 2 and 3) may have occurred because of ration ingredient combinations being used that was not totally acceptable to the pigs. Furthermore, the results indicate that either the assumed nutritional values of some of the feed ingredients used were overestimated or the requirements of the pigs were underestimated.

Although performance of pigs fed the least cost rations was not as high as expected, the pigs on treatment 3, fed a least cost computer ration reformulated every 29 days had a lower feed ingredient cost per pound of gain than the pigs on the other two treatments.

Introduction

The current high feed costs of livestock producers have resulted in an increased interest in the use of least cost computer rations in an effort to reduce feed costs. This method of ration formulation has gained wide acceptance by industry and university personnel working in the area of swine nutrition. It is often used as a tool to save time in formulating rations and to get ideas on saving costs. When the actual ration is to be used it is often altered by the nutritionist in an effort to make it more acceptable to the pig.

It was deemed feasible to conduct a study measuring performance of pigs fed least cost computer swine rations without making any alterations in the computer output. When alterations are made, the actual ingredient cost of the ration is often increased.

Experimental Procedure

Sixty Hampshire, Yorkshire, and Hampshire X Yorkshire pigs were used in this study conducted in the summer of 1973. The pigs averaging 53.6 pounds were randomly allotted within breed, sex and litter to three experimental treatments with 10 pens (two pigs per pen) in each treatment. All pigs were housed in indoor concrete pens equipped with self feeders and automatic waterers. Pigs completing the experiment were individually removed from test on a weekly basis when they reached 210 pounds.

The treatments were as follows:

Treatment 1. Pigs were fed a grain sorghum-soybean meal basal ration with a crude protein content of 16 percent the first 29 days (period 1) and 14 percent thereafter for the duration of the experiment (period 2 through 4). See Table 1.

Treatment 2. Pigs were fed a 16 percent crude protein least cost ration for 29 days (period 1) and a 14 percent thereafter for the duration of the experiment (periods 2 through 4). The computer was allowed to use only the ingredients for the 14 percent ration that it had selected for the 16 percent crude protein ration.

Treatment 3. Pigs were fed a least cost computer ration with a crude protein content of 16 percent for the first 29 days. It was the same ration as fed to pigs on treatment 2. Thereafter, a 14 percent crude protein, least cost computer ration was formulated every 29 days (periods 2 through 4) using current prices of feedstuffs. See Table 1.

Nutritional specifications programmed into the computer for ration formulation are shown in Table 2. Vitamin and trace mineral supplementation, digestible energy, calcium, phosphorus, and crude protein content were held constant in all rations. Minimum levels of lysine, threonine, trytophane and methionine were above requirements suggested by the National Research Council, 1968. However, the exact level of these amino acids were not constant in all rations as shown in Table 1. Fiber content although not constant was similar in all rations as shown in Table 1.

Prices used for feedstuffs during all four periods of the experiment are shown in Table 3. The prices used were obtained from a local feed mill in Stillwater, Oklahoma on the day the ration was formulated. The prices were the cost of the ingredient delivered to Stillwater, Oklahoma in railroad car lots. The computer chose during one or more periods all the ingredients prices with the exception of dehydrated alfalfa meal and cane molasses.

The ingredient cost of the rations computed are shown in Table 4. The cost figures given are for ingredients only. No estimated costs were added for grinding, mixing, hauling, storage, etc. The experiment was conducted during a period of rising feed prices which accounts for the gradual increase in prices from periods 1 through 4.

Results and Discussion

Period 1

The results are shown in Table 5. Pigs on treatment 1 had a significantly higher ($P<.01$) average daily gain and significantly higher ($P<.05$) average daily feed intake than pigs on treatments 2 and 3. Little difference was noted among treatments for feed conversion. Feed ingredient cost per pound of gain did not differ greatly among treatments being 15.4, 15.6, and 15.1¢ for treatments 1 through 3 respectively.

It is apparent from the significantly lower feed intake for the pigs on treatments 2 and 3 that the ration fed to those pigs was less palatable than the ration fed to the pigs on treatment 1. However a perusal of the

Table 1. Composition of Experimental Rations

Ingredients	Treatment 1 (Per 1)	Treatment 2 & 3 (Per 1)	Treatment 1 (Per 2,3,4)	Treatment 2 (Per 2,3,4)	Treatment 3 (Per 2)	Treatment 3 (Per 3)	Treatment 3 (Per 4)
Yellow corn		62.97		63.48	65.66		67.81
Grain sorghum	75.80		81.50				
Barley		14.76		20.12			
Wheat						71.45	
Wheat mixed feed					15.97	12.33	17.83
Soybean meal (44%)	20.90	13.19	15.20	7.65			8.41
Peanut meal (50%)		5.81		5.42	3.59	2.01	2.83
Meat and bone scrap (50%)					4.57	3.20	
Dried whey product (17%)					9.08	9.65	
Calcium carbonate	0.80	0.85	0.80	0.83	0.41	0.64	1.10
Dicalcium phosphate	1.50	1.42	1.50	1.50			1.02
Salt	0.50	0.50	0.50	0.50	0.22	0.22	0.50
Vitamin-trace mineral mix[1]	0.50	0.50	1.50	0.50	0.50	0.50	0.50
Total, %	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Content							
Crude Fiber, %	3.51	3.94	3.26	3.91	3.54	3.14	4.09
D E., Mcal, lb.	1.49	1.49	1.49	1.49	1.49	1.49	1.49
Crude protein, %	16.00	16.00	14.00	14.00	14.00	14.00	14.00
Calcium, %	0.70	0.70	0.69	0.70	0.70	0.70	0.70
Phosphorus, %	0.60	0.60	0.59	0.60	0.62	0.60	0.60
Lysine, %	0.83	0.70	0.64	0.55	0.55	0.55	0.55
Threonine, %	0.59	0.62	0.48	0.54	0.55	0.48	0.55
Tryptophane, %	0.20	0.20	0.17	0.17	0.16	0.19	0.17
Methionine, %	0.25	0.25	0.23	0.22	0.26	0.26	0.24
Methionine & Cystine, %	0.53	0.52	0.48	0.46	0.49	0.59	0.46

[1] Supplied 3,000,000 IU vitamin A, 300,000 IU vitamin D, 4 gm riboflavin, 20 gm pantothenic acid, 30 gm niacin, 1,000 gm choline chloride, 15 mg vitamin B_{12}, 6,000 IU vitamin E, 20 gm menadione, 0.2 gm iodine, 90 gm iron, 20 gm manganese, 10 gm copper, 90 gm zinc, and 50 gm chlorotetracycline per ton of feed.

Table 2. Nutritional Specifications used in Least Cost Computer Rations

	16% rations		14% rations	
	minimum	maximum	minimum	maximum
Crude fiber, %	----	5.00	----	6.00
Digestible Energy, Mcal per lb.	1.49	1.49	1.49	1.49
Crude protein, %	16.00	16.00	14.00	14.00
Calcium, %	0.70	0.72	0.70	0.72
Phosphorus, %	0.60	0.62	0.60	0.62
Lysine, %	0.70	----	0.55	----
Threonine, %	0.45	----	0.40	----
Tryptophane, %	0.13	----	0.09	----
Methionine, %	0.25	----	0.20	----
Methionine & Cystine, %	0.50	----	0.40	----
Vitamin-trace mineral mix[1]	0.50	0.50	0.50	0.50

[1] Composition given in footnote[1] of Table 1.

Table 3. Prices of Feedstuffs Used in Computer Rations

Ingredients	Price per Cwt., $ Period 1	Price per Cwt., $ Period 2	Price per Cwt., $ Period 3	Price per Cwt., $ Period 4
Yellow corn	3.45	4.38	4.73	5.35
Grain sorghum	3.15	3.75	3.95	5.50
Barley	3.10	3.10	3.30	5.50
Wheat	4.15	5.00	5.00	8.83
Wheat mixed feed	4.15	3.50	3.85	6.25
Soybean meal (44%)	14.00	14.00	20.00	18.00
Peanut meal (50%)	12.25	20.00	20.00	20.00
Meat and bone scraps (50%)	15.75	20.00	23.00	23.00
Dried whey product (17%)	6.50	6.60	6.60	*[1]
Dehydrated alfalfa meal (17%)	3.50	3.50	3.75	5.00
Cane molasses (wet)	3.43	3.50	3.50	3.75
Calcium carbonate	0.80	0.80	0.80	0.80
Dicalcium phosphate	4.50	4.50	4.50	4.50
Salt	1.25	1.25	1.25	1.25
Vitamin-trace mineral mix	16.00	16.00	16.00	16.00

[1] Dried whey product was not available during Period 4.

Table 4. Ingredient Cost of Experimental Rations

Period	Treatments 1	2	3
1	$5.47/cwt.	$5.35/cwt.	$5.35/cwt.
2	6.56	6.33	5.74
3	6.42	6.44	5.90
4	7.38	7.12	6.96

rations would not suggest this. The energy and protein ingredients fed to the pigs on treatments 2 and 3 during Period 1 was yellow corn, barley, soybean meal and peanut meal compared to grain sorghum and soybean meal fed to pigs on treatment 1. See Table 1. One would not normally suspect a large difference in feed intake between the two rations. There was a considerable difference in lysine content of the rations fed to pigs on treatment 1 versus the rations fed to pigs on treatments 2 and 3 (0.83 vs. 0.70 percent). However, the calculated lysine content (0.70 percent) of the rations fed to pigs on treatments 2 and 3 does meet the requirements set forth by the National Research Council, 1968.

Period 2

The results are shown in Table 6. Pigs tended to gain faster on treatment 1 but no significant differences were noted among treatments. No significant differences were likewise noted in feed conversion but the pigs

Table 5. Performance of Pigs on Least Cost Computer Rations — Period 1.

	Treatments		
	1	2	3
Av. initial, wt., lb.	53.2	53.6	54.1
Av. final wt., lb.	92.5	85.8	87.7
No. of days on test	29	29	29
Av. daily gain, l.*	1.36[1]	1.11[2]	1.16[2]
Feed per lb. gain, lb.	2.82	2.92	2.83
Av. daily feed intake, lb.**	3.82[1]	3.22[2]	3.28[2]
Feed ingredient cost per lb. gain, ¢	15.4	15.6	15.1

* Means with different superscripts are significantly different ($P<.01$)
** Means with different superscripts are significantly different ($P<.05$)

Table 6. Performance of Pigs on Least Cost Computer Rations — Period 2.

	Treatments		
	1	2	3
Av. initial wt., lb.	92.5	85.8	87.7
Av. final wt., lb.	133.4	124.2	123.0
No. of days on test	29	29	29
Av. daily gain, lb.	1.41	1.32	1.22
Feed per lb. gain, lb.	3.58	3.50	3.23
Av. daily feed intake, lb.*	4.99[1]	4.53[1,2]	3.93[2]
Feed ingredient cost per lb. gain, ¢	23.5	22.2	18.5

* Means with different superscripts are significantly different ($P<.05$)

on treatment 3 tended to require less feed per pound of gain. The pigs on treatment 1 had the highest average daily feed intake (4.99 pounds) and was significantly higher ($P<.05$) than the 3.93 pounds for the pigs on treatment 3. Feed cost per pound of gain was 23.5, 22.2, and 18.5¢ for the pigs on treatments 1 through 3 respectively.

Although feed ingredients cost per pound of gain was appreciably lower for the least cost rations (treatments 2 and 3), the decreased feed intake of the pigs on these rations still indicate a palatability problem. The combination of yellow corn, wheat mixed feed, peanut meal, meat and bone scraps and dried whey product as shown in Table 1 was apparently not an acceptable diet for the pigs on treatment 3. The complete absence of soybean meal may have been a factor too. Again the lower lysine content of the ration fed to the pigs on treatments 2 and 3 (0.55 percent) as compared to the lysine content of 0.64 percent of the ration fed pigs on treatment 1 may be a factor also.

Period 3

The results are shown in Table 7. Pigs on treatment 1 had a significantly higher ($P<.01$) average daily gain of 1.72 pounds as compared to 1.42 and 1.44 pounds for pigs on treatments 2 and 3 respectively. No significant differences were noted in feed required per pound of gain or average daily feed intake. However, the pigs on treatment 1 tended to require less feed per pound of gain and to have a higher daily feed intake than the pigs on the other two treatments. Feed ingredient cost per pound of gain was 19.1, 20.7, and 18.4¢ for treatments 1 through 3 respectively.

The lowered feed intake of the pigs on treatments 2 and 3 may largely explain the significantly lower daily gains. The grains selected by the computer for the pigs on treatment 3 during period 3 was wheat. However, previous research conducted at this station has not shown the feed-

Table 7. Performance of Pigs on Least Cost Computer Rations — Period 3.

	Treatments		
	1	2	3
Av. initial wt., lb.	133.4	124.2	123.0
Av. final wt., lb.	183.2	165.4	164.8
No. of days on test	29	29	20
Av. daily gain, lb.[1]	1.72[a]	1.42[a]	1.44[a]
Feed per lb., gain, lb.	2.98	3.22	3.12
Av. daily feed intake, lb.	5.20	4.60	4.50
Feed ingredient cost per lb. gain, ¢	19.1	20.7	18.4

[a] Means with different superscripts are significantly different ($P\leq.01$).

ing of wheat to cause a major reduction in feed intake. However, the complete absence of soybean meal from the ration may have been a factor in the reduced feed consumption.

The reason for the decreased feed intake of the pigs on treatment 2 is not as apparent as the grain portion of the ration was 63.48 percent yellow corn and 20.12 percent barley. Likewise, the protein ingredients used was 7.65 percent soybean meal and 5.24 percent peanut meal.

Period 4

The results are shown in Table 8. Pigs were removed individually from test during this period when they reached 210 pounds. Therefore, the average number of days on test is less than the 29 days shown for the other three periods.

No significant differences were noted among treatments for daily gain, feed conversion or daily feed intake. However, the pigs on treatment 1 tended to require less feed per pound of gain. Feed ingredient cost per pound of gain was 24.6, 26.6, and 25.4¢ for treatments 1 through 3 respectively.

Total Period

Performance data as shown in Table 9 was computed for the total feeding period. Average daily gains were 1.58, 1.39, and 1.43 pounds for treatments 1 through 3 respectively. The gains for the pigs on treatment 1 were significantly higher ($P<.05$) than those on treatment 2. No significant differences were noted in feed required per pound of gain or average daily feed intake but the pigs on treatment 1 tended to require less feed per pound of gain and have a higher average daily feed intake.

The lower daily gains of the pigs on treatments 2 and 3 fed the least cost computer rations as compared to those fed on treatment 1 is largely explained by the decreased feed intake. Apparently the combination of

Table 8. Performance of Pigs on Least Cost Computer Rations — Period 4.

	Treatments		
	1	2	3
Av. initial wt., lb.	178.0	162.2	163.6
Av. final wt., lb.	212.2	200.0	209.5
Av. no. of days on test	17.7	20.3	24.2
Av. daily gain, lb.	1.93	1.87	1.94
Feed per lb. gain, lb.	3.34	3.73	3.65
Av. daily feed intake, lb.	6.39	6.96	7.02
Feed ingredient cost per lb. gain, ¢	24.6	26.6	25.4

Table 9. Performance on Pigs of Least Cost Computer Rations — Total Period.

	Treatments		
	1	2	3
Pens per treatment, no.	10	10	10
Pigs per pen, no.	2	2	2
Av. initial wt., lb.	53.2	53.6	54.1
Av. final wt., lb.	213.4	202.0	210.2
Av. no. of days on test	102.8	107.2	109.9
Av. daily gain, lb.	1.58[1]	1.39[2]	1.43[1,2]
Feed per lb. gain, lb.	3.15	3.34	3.20
Av. daily feed intake, lb.	4.95	4.63	4.47
Feed ingredient cost per lb. gain, ¢	20.4	21.5	19.8

* Means with different superscripts are significantly different ($P < .01$)

ingredients selected by the computer was not totally acceptable to the pigs. The decreased lysine content of the rations fed the pigs on treatment 2 and 3 may have been a factor also. However, the calculated lysine content of these rations met the requirements set forth by the National Research Council, 1968.

It would appear that by holding digestible energy, calcium, phosphorus, and crude protein constant in all rations and meeting all other known requirements of swine, one should be able to formulate on the basis of least cost using various ingredients. It is obvious from this data that our knowledge of feed ingredients for some feedstuffs available may be limited.

The average feed ingredient cost per pound of gain for the total period was 20.4, 21.5, and 19.8¢ for treatments 1 through 3 respectively. The lower feed cost per pound of gain for the pigs on treatment 3 (least cost rations reformulated every 29 days) would result in a savings of approximately 95¢ per pig as compared to the pigs fed the control ration on treatment 1. However, part of this savings is lost since the pigs gained slower and took approximately seven more days to reach market weight; therefore increasing fixed costs. The higher feed ingredient cost per pound of gain for the pigs on treatment 2 (a least cost ration fed throughout the trial) actually resulted in an increased cost of approximately $1.40 per pig as compared to the pigs fed the control ration on treatment 1. This demonstrates that although the ingredient cost of a ration may be the cheapest, it may yet result in an increase in cost of gains if the ration itself is not acceptable to the pig.

Sheep

Carcass Traits of Wethers Produced by Crossbred Dams of Rambouillet, Dorset and Finnsheep Breeding and Slaughtered at Two Weights

David L. Thomas, Joe V. Whiteman, Lowell E. Walters and John E. Fields

Story in Brief

Carcass characteristics of 60 wether lambs born in January and February, 1974, from matings of blackfaced rams with crossbred ewes of Rambouillet (R), Dorset (D), and Finnsheep (F) breeding were evaluated by slaughter at approximately 100 or 125 pounds live weight. The breeding of the five dam breed combinations was as follows: ¼F½D¼R, ¼F¼D½R, ¼F¾R, ½D½R, and ¼D¾R.

When slaughtered at approximately 100 pounds, there was little difference among the lambs produced by the five dam breed combinations in measures of external finish and percent major trimmed cuts. There was a slight tendency for lambs produced by ¼ Finnsheep ewes to have smaller loin eye areas and a greater percent kidney, heart and pelvic fat than lambs from dams of Dorset and Rambouillet breeding only. There was also a tendency for lambs from one-half Dorset dams to exceed lambs from one-quarter Dorset dams in most measures of fatness.

When slaughtered at approximately 125 pounds, the differences among the lambs produced by the five dam breed combinations were larger and significant for some of the traits studied. Lambs from ¼F¾R dams had loin eye areas significantly smaller than those of lambs from ¼D¾R, and ¼F½D¼R dams. Lambs from ¼F¼D½R and ¼F¾R dams had significantly greater percent kidney, heart and pelvic fat than lambs from ½D½R dams. ½D½R dams also produced lambs that had a

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significantly greater fat probe over the rump, a smaller hind saddle specific gravity and a greater percent fat trim from the major cuts.

When the thirty 100 pound lambs were compared with the thirty 125 pound lambs, significant differences were found for all carcass traits studied. The heavier lambs produced carcasses that were fatter, yielded a lower percent trimmed major cuts, and had larger loin eye areas than carcasses produced by lighter lambs. However, both the light and heavy lambs yielded about the same proportion of their respective live weights in pounds of trimmed major wholesale cuts.

Introduction

The improvement of reproductive efficiency which results in more lambs born per ewe maintained is of great economic concern to the commercial sheepman. Recent studies of the Finnish Landrace (Finnsheep) breed of sheep and some of their crosses in the United States has shown them to be younger at sexual maturity and to give birth to more lambs per ewe lambing under spring lambing conditions than the domestic breeds with which they have been compared. Thus, in an attempt to increase profit, commercial sheepman may be tempted to infuse their flocks with Finnsheep germ plasma without first considering the subsequent effects, if any, on the quality and quantity of wool and lamb produced.

The purpose of this study is to evaluate the carcass characteristics of lambs produced by mating blackfaced rams to crossbred ewes of Rambouillet, Dorset and Finnsheep breeding when slaughtered at approximately 100 or 125 pounds live weight.

Materials and Methods

These data include the carcass characteristics of 60 wether lambs born in January and February, 1974, at the Ft. Reno Livestock Research Station, El Reno. They were produced from crossbred ewes of five combinations of Rambouillet (R), Dorset (D), and Finnsheep (F) breeding involved in a study to evaluate lifetime reproductive performance under Oklahoma conditions. Twelve lambs were randomly selected from dams of each of the following five breed combinations: ¼F½D¼R, ¼F¼D ½R, ¼F¾R, ½D½R and ¼D¾R. Six of the lambs selected from dams of each breed combination were designated for slaughter at approximately 100 pounds full weight and the remaining six at 125 pounds. The lambs were sired by 2 Hampshire and 4 Suffolk sires with 10 lambs produced from each sire (one lamb for each of the 10 dam breed combination—slaughter weight classes).

The lambs were docked and castrated prior to one week of age, allowed access to early spring wheat pasture with their dams and fed a ground creep ration containing the following ingredients:

Alfalfa	40 percent
Milo	45 percent
Molasses	5 percent
Soybean Oil Meal	10 percent

They were weaned at approximately 70 days of age and finished in drylot on a ration similar to the creep ration but with the soybean oil meal deleted and the alfalfa and milo each increased by 5 percent.

All test lambs were weighed full each week and sheared when reaching 100 pounds. Upon reaching their designated slaughter weight of 100 or 125 pounds, the lambs were trucked to Stillwater and slaughtered at the O.S.U. Meats Laboratory after a 24-hour shrink period. Twenty-four hours post slaughter the carcasses were ribbed between the 12th and 13th rib perpendicular to the line of the back, loin eye area tracings taken, fat thicknesses measured over the loin eye, a fat probe taken over the rump approximately three inches below the base of the dock and a specific gravity reading of the hind saddle recorded.

Forty-eight hours postslaughter the carcasses were divided into wholesale cuts. The four major wholesale cuts (shoulder, rack, loin, and leg) of the left side were trimmed to an average of 0.2 inches of fat. All subcutaneous fat of these same cuts of the right side was removed and in addition, the shoulder and leg were completely boned. The breasts, shanks and flanks of both sides were handled similarly with the shanks and flanks being completely separated into lean trim, fat trim and bone and with the breasts having all subcutaneous fat removed and being partially boned. Both the front and rear cannon bones of each side were completely trimmed of soft tissue and weighed.

Results and Dicsussion[1]

At the present time the majority of the fat lambs in the United States are slaughtered at approximately 100 pounds, but in recent years there has been increased interest in carrying lambs to heavier weights. With this interest in mind, the lambs from the five dam breed combinations were evaluated at two different weights. Tables 1 and 2 give the mean values of some general carcass traits of lambs produced by the five dam breed combinations when the lambs were slaughtered at either the traditional 100 pounds or a heavier weight or 125 pounds.

[1] It is highly likely that many of the differences in carcass traits are not real, but due to chance. Where there is strong evidence to suggest that a difference is real, the word "significant" or "significantly" is used to denote this difference.

The three dam breed combinations of ¼F½D¼R, ¼F¼D½R and ¼F¾R show a progressive substitution of one-quarter Rambouillet for one-quarter Dorset. We would thus expect the lambs produced by ¼F¼D½R dams to be intermediate for the carcass traits studied when compared with lambs from the other two dam breed combinations. This is generally the case with the 125 pound lambs as shown in Table 2. At 100 pounds, however, the lambs from the ¼F¼D½R dams are superior to lambs from the other two dam breed combinations in most measures of leanness and trimness. Since there is no logical explanation for this, it is thought that by chance, the lambs chosen from this group were leaner than the average of the breed group as a whole.

Table 1 indicates that the breed combination of the ewes had little influence on most of the traits studied when the lambs were slaughtered at 100 pounds. Lambs produced from all dam breed combinations were acceptable in quality; grading either average or high choice. Leg conformation scores were also acceptable with all groups scoring average choice except lambs produced from ¼D¾R dams.

Lambs produced by ¼F½D¼R dams had greater dressing percents than lambs produced by any other dam breed combination. It would appear that the higher dressing percent of these lambs is due to a tendency for lambs of this breeding to have the highest percent kidney, heart and

Table 1. Carcass Traits of Lambs Produced by Crossbred Dams of Rambouillet, Dorset and Finnsheep Breeding and Slaughtered at Approximately 100 pounds.*

	Breed Combination of Dam				
Carcass Trait	¼F½D¼R	¼F¼D½R	¼F¾R	½D½R	¼D¾R
Quality Grade**	12.00	11.67	11.17	11.83	11.50
Dressing %	49.16[1]	46.73[2]	47.45[1,2]	47.18[1,2]	47.80[1,2]
Leg Conf. Score**	11.00	11.67	11.17	11.67	10.83
Loin Eye Area (in.^{2})	2.07	2.03	1.98	2.18	2.11
% K H P Fat	3.95	3.20	3.30	3.02	2.96
Fat Thick. over Loin Eye (in.)	0.24	0.17	0.23	0.23	0.21
Fat Probe over Rump (in.)	0.44	0.39	0.44	0.57	0.45
Hind Saddle Specific Gravity	1.0423	1.0504	1.0472	1.0478	1.0472
Cannon Bone Wt. (lb.)	0.328[1,2]	0.357[1]	0.322[1,2]	0.308[2]	0.331[1,2]
% Trimmed Major Cuts of Right Side	57.35	58.92	57.41	58.30	58.40
% Fat Trim from Major Cuts of Right Side	12.71	11.11	12.50	12.42	11.44

* Different Superscripts in the same row indicate significance at the $P \leq .05$ level meaning that the differences are probably indicative of real differences.
** 10 = Low Choice, 11 = Average Choice, 12 = High Choice.

pelvic fat and a high degree of external finish as indicated by the percent fat trim from the major wholesale cuts of the right side. These data also indicate a tendency for lambs from dams containing one-half Dorset blood to be fatter than lambs from one-quarter Dorset dams.

Also, interesting to note, is that the lambs produced by dams with some Finnsheep breeding tended to have a higher percent kidney, heart and pelvic fat and smaller loin eye areas than lambs from Dorset and Rambouillet breeding only. The differences were small, however.

The weight of the four cannon bones, a good indicator of total carcass bone, was significantly greater for lambs from ¼F¼D½R dams than for lambs from ½D½R dams. This finding is very interesting since the Finnsheep breed is thought to be "lighter-boned" than most of our domestic breeds. A similar relationship existed between dam's breed combination and cannon bone weight for the lambs slaughtered at about 125 pounds.

The percent trimmed major cuts of right side, our best indicator of percent lean, was not significantly different among the five dam breed combinations. These data would indicate that lambs produced by all five dam breed combinations were similar in the carcass traits studied when slaughtered at 100 pounds.

Table 2 presents the mean values of general carcass traits of lambs produced by the five dam breed conmbinations and slaughtered at approximately 125 pounds. More of the mean values of the various carcass traits were significantly different among dam breed combinations at 125 pounds than at 100 pounds. This suggests that the five groups of lambs may mature at different rates with some groups depositing excess fat at lighter weights than others.

Carcass quality grades were significantly greater for lambs produced by ¼D¾R and ¼F¼D½R dams when compared with lambs produced by ¼F½D¼R dams. These differences are, however, of little practical significance since lambs from all five dam breed combinations averaged high choice or low prime in quality grade. Leg conformation scores were very acceptable with all five groups of lambs having scores of average or high choice.

Dressing percents were not significantly different among the five groups, but lambs from ½D½R dams exceeded others in this trait. These lambs also had a significantly greater fat probe over the rump, a lower hind saddle specific gravity reading and a greater percent fat trim from the major wholesale cuts of the right side when compared with lambs from the other four dam breed combinations. These are all indicators that the lmabs from ½D½R dams mature earlier and tend to deposit more fatty tissue subcutaneously at 125 pounds than lambs of the other

Table 2. Carcass Traits of Lambs Produced by Crossbred Dams of Rambouillet, Dorset and Finnsheep Breeding and Slaughtered at Approximately 125 Pounds.*

Carcass	Breed Combination of Dam				
	¼F½D¼R	¼F¼D½R	¼F¾R	½D½R	¼D¾R
Quality Grade**	12.00^{3}	13.33^{1-2}	12.83^{2-3}	12.83^{2-3}	13.83^{1}
Dressing %	50.28	50.75	50.90	51.65	50.84
Leg Conf. Score**	12.83	11.67	11.67	11.83	12.17
Loin Eye Area (in.^{2})	2.47^{1}	2.40^{1-2}	2.20^{2}	2.53^{1}	2.48^{1}
% K H P Fat	4.90^{1-2}	5.45^{1}	5.66^{1}	4.28^{2}	4.71^{1-2}
Fat Thick. over Loin Eye (in.)	0.31	0.34	0.38	0.38	0.32
Fat Probe over Rump (in.)	0.66^{2}	0.80^{2}	0.72^{2}	1.00^{1}	0.72^{2}
Hind Saddle Specific Gravity	1.0369	1.0367	1.0358	1.0340	1.0362
Cannon Bone Wt. (lb.)	0.371^{1}	0.387^{1}	0.368^{1-2}	0.333^{2}	0.370^{1}
% Trimmed Major Cuts of Right Side	54.80	53.76	52.64	53.42	54.94
% Fat Trim from Major Cuts of Right Side	14.34^{2}	15.29^{1-2}	16.03^{1-2}	17.55^{1}	15.15^{1-2}

* Different Superscripts in the same row indicate significance at the $P < .05$ level meaning that the differences are probably indicative of real differences.
** 11 = Average Choice, 12 = High Choice, 13 = Low Prime.

groups. Also, lambs produced by ½D½R ewes were not exceeded in fat thickness over the loin eye by lambs of any other group.

Lambs from ¼F¼D½R and ¼F¾R dams had significantly greater percent kidney, heart and pelvic fat than lambs from ½D½R dams. The fact that lambs from ½D½R dams equaled or exceeded all other groups in measures of external finish, but were exceeded by lambs from dams with some Finnsheep breeding in percent kidney, heart and pelvic fat is very interesting. Other researchers working with pure, one-half and one-quarter Finnsheep wethers have also shown that wethers of Finnsheep breeding exceed wethers of domestic breeding in percent kidney, heart and pelvic fat. The lambs in this study of Finnsheep breeding are one-eighth Finnsheep, and they also exhibit this tendency. The Finnsheep breed is evidently very prepotent for this trait.

Lambs from ½D½R, ¼D¾R and ¼F½D¼R dams had significantly larger loin eye areas than lambs from ¼F¾R dams. These data imply that acceptable loin eye areas can be maintained in lambs from one-quarter Finnsheep ewes if they also contain at least a quarter Dorset. The lambs from ¼F¾R dams also had the lowest percent trimmed major wholesale cuts of the right side.

Weight of the four cannon bones was significantly greater for lambs from ¼F¼D½R, ¼F½D¼R and ¼D¾R dams than for lambs from

½D½R dams. This ranking of the dam breed combinations as to cannon bone weight agrees quite well with the data from the 100 pound lambs.

These results indicate that when slaughtered at 125 pounds, lambs from ¼F¾R dams had the greatest percent kidney, heart and pelvic fat, the smallest loin eye areas and the least percent trimmed major wholesale cuts of right side. Lambs from ½D½R dams had the greatest fat probe over the rump and the greatest percent fat trim from the major wholesale cuts of right side. Lambs from ¼D¾R, ¼F¼D½R and ¼F ½D¼R dams were comparable in many carcass traits and produced the most acceptable carcasses of the five groups when slaughtered at 125 pounds.

Slaughter Weight

Table 3 gives the mean values of various carcass traits of wether lambs slaughtered at approximately 100 or 125 pounds live weight and averaged over the five dam breed combinations. It is quite evident that

Table 3. Carcass Traits of Crossbred Lambs Slaughtered at Approximately 100 or 125 Pounds.

Carcass Trait	Approximate Slaughter Weight**		Percent Change
	100 Pounds	125 Pounds	
Actual Slaughter Wt. (lb.)	101.57	125.90	+24.0
Quality Grade*	11.63	12.97	+11.5
Dressing %	47.67	50.88	+ 6.7
Leg. Conf. Score*	11.27	12.03	+ 6.7
Loin Eye Area (in.^{2})	2.07	2.42	+16.9
% K H P Fat	3.28	5.00	+52.4
Fat Thick. over Loin Eye (in.)	0.22	0.34	+54.5
Fat Probe over Rump (in.)	0.46	0.78	+69.6
Hind Saddle Specific Gravity	1.0470	1.0360	— 1.1
Cannon Bone Wt. (lb.)	0.329	0.366	+11.2
Trimmed Major Cuts of Right Side (lb.)	13.88	17.07	+23.0
% Trimmed Major Cuts of Right Side of Carcass	58.07	53.91	— 7.2
% Trimmed Major Cuts of Slaughter Wt.	27.33	27.12	— 0.8
Fat Trim from Major Cuts of Right Side (lb.)	2.89	4.96	+71.6
% Fat Trim from Major Cuts of Right Side of Carcass	12.04	15.67	+30.1
% Fat Trim from Major Cuts of Slaughter Wt.	5.69	7.88	+38.5

* 11 = Average Choice, 12 = High Choice.
** All differences among weight groups are significantly different at the P<.05 level except "% Trimmed Major Cuts of Slaughter Wt."

increasing slaughter weight by approximately 25 pounds had a definite effect on these traits. All but one of the mean values of the various traits were significantly different among the two weight groups with lambs slaughtered at 125 pounds possessing more fatty tissue than lambs slaughtered at 100 pounds. This resulted in a greater percent fat trim from the major wholesale cuts of the right side and a lower percent trimmed major wholesale cuts of the right side for lambs slaughtered at 125 pounds.

The heavy lambs were, however, superior to the lighter lambs in quality grade, leg conformation score (probably due to increased fat deposition) and loin eye area. Increased loin eye area is of economic importance to the sheep industry in order to gain consumer acceptance of the high priced retail loin cuts. However, increasing loin eye areas by increasing slaughter weights of wether lambs from populations that have been selected to finish properly at lighter weights has been shown to lower percent trimmed major wholesale cuts, (edible portion).

Table 3 also shows changes in carcass composition as the slaughter weight went from 100 to 125 pounds. Considered on a percentage of carcass weight basis trimmed major cuts of right side decreased and fat trim from these cuts increased when slaughter weights increased. If we consider these two measurements to be good indicators of carcass lean and fat, then lean in the carcass increased at a slower rate between 100 and 125 pounds live weight than did fat. When these two measurements are expressed as a percentage of live weight, however, there is less difference between the two weight groups in the proportion of lean as indicated by trimmed major cuts or fat as indicated by the fat trim.

These data indicate that crossbred lambs sired by blackfaced rams will yield about the same proportion of their live weight in pounds of trimmed major cuts at live weights of 100 and 125 pounds. The 125 pound lambs' carcasses will be fatter, however, because between 100 and 125 pounds the lambs add relatively more fat which increases the dressing percentage and the carcass fat trim. This is why meat marketing personnel often object to heavy lamb carcasses as being too wasteful.

A Further Report of the Productivity of Crossbred Ewes of Finnsheep, Dorset and Rambouillet Breeding

David L. Thomas, Joe V. Whiteman and John E. Fields

Story in Brief

In March-April of 1971 and 1972, about 250 crossbred ewe lambs were born at the Fort Reno Experiment Station of the following breed combinations: ½Dorset ½Rambouillet, ¼Dorset, ¾Rambouillet, ¼Finnsheep ¾Rambouillet, ¼Finnsheep ¼Dorset ½Rambouillet, and ¼Finnsheep ½Dorset ¼Rambouillet. The lambing performance of these five breeding groups has been reported previously for the years of 1972 and 1973. In 1974, the ewes were converted from a spring to a fall lambing program and lambed in January-February and again in October-February.

When lambing in January-February, the ½ Dorset ½ Rambouillet group excelled in reproductive performance with the highest percent ewes lambing (98) and the highest lahbing rate (1.75). Other groups were similar for percent ewes, lambings, and both ¾Rambouillet groups were the lowest in lambing rate ($\sim$1.50).

When lambing in October-November, percent ewes lambing was unusually low for all breeding groups. The ½D½R group had the highest percent ewes lambing (80). Of the ¼D¾R ewes, 73 percent lambed and the ¼ Finnsheep groups exhibited 57 percent to 63 percent ewes lambing. Lambing rates were highest for the two ¼ Finnsheep groups that contained both Dorset and Rambouillet breeding.

Fleece information from the 1974 clip showed that the breeding groups containing the greatest proportion of Rambouillet breeding produced the heaviest, highest grading fleeces. The influence of the Finnsheep breeding on wool quantity and quality appeared to be about the same as the influence of the Dorset breeding.

Introduction

The most productive mating system for commercial sheepmen usually involves a three-way cross. The ewe flock needs to be a cross between two breeds with high productive rates, and these crossbred ewes should be mated to rams that produce growthy lambs with good carcasses. Past research at Fort Reno has established the superority of the lambs from

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Dorset X Rambouillet ewes bred to good blackfaced rams for this purpose.

During the past few years a very limited number of Finnish Landrace (Finnsheep) sheep have been brought into the United States. This breed excels in lambing rate in their native country. In 1971 and 1972, crossbred ewes combining Finnsheep, Dorset and Rambouillet breeding were produced in order to evaluate their lifetime reproductive performance.

The growth rate of these ewes as lambs and some carcass characteristics of some of the male lambs were reviewed in the 1972 and 1973 Animal Sciences and Industry Research Reports (MP-87 and MP-90). The reproductive performance of all the ewes when lambing at approximately 12 months of age and approximately one-half the ewes when lambing at 24 months of age in the spring was reviewed in the same publication in 1974 (MP-92). Reproductive rate at one year of age showed a consistent advantage for the two ¼ Finnsheep groups that contained both Dorset and Rambouillet breeding. Reproductive rate at two years of age showed a small advantage for the ¼ Finnsheep ewes.

This report deals with the reproductive performance of these same ewes when lambing in both January-February and October-November, 1974, and information on their fleece yields and grades from the 1974 clip.

Experimental Procedure

The ewes constituting this flock are of five different breeding groups containing Finnsheep (F), Dorset (D) and Rambouillet (R) breeding. They are as follows: ¼F½D¼R, ¼F¼D½R, ¼F¾R, ¼D¾R and ½D½R. Approximately one-half of the ewes in each breeding group were born in the spring of each of the years of 1971 and 1972 except the ¼F¾R ewes which were all born in 1972. The manner in which they were reared and their lambing performance in 1972 and 1973 has been reviewed previously.

The ewes were mated to blackfaced rams over about a 50 day breeding season starting in August, 1973. They lambed in January-February, 1974, and had their lambs weaned at approximately 70 days of age. In order to put the entire flock onto a fall lambing program, the ewes were remated to blackfaced rams in May-June, 1974 and, consequently, lambed again in October-November, 1974. Their lambs were weaned at about 70 days of age.

Results and Discussion

Lambing Performance

Table 1 presents the lambing results of the five breeding groups when lambing in January-February, 1974. The ewes born in 1971 (first replicate) were coming three-year-olds and the ewes born in 1972 (second replicate) were coming two-year-olds.

In both replicates, the ½D½R ewes produced more lambs per ewe exposed than did any other group. In the first replicate the ¼ Finnsheep ewes ranked second and performed well as coming three-year-olds. The ¼D¾R ewes ranked last in lambs per ewe exposed due primarily to a poorer lambing rate. In the second replicate, the two ¼ Finnsheep groups containing both Dorset and Rambouillet breeding produced a poor lamb crop due primarily to a large percentage of the ewes not lambing since they did have the highest lambing rates of any of the groups. The ¼D¾R and ¼F¾R produced poor lamb crops due to both an average lambing rate and average proportion of the ewes exposed lambing. These results may indicate that the ½D½R ewe, as a relatively prolific crossbred, is better adapted to the hot summer climate of an Oklahoma August (when these ewes were mated) than ewes containing some Finnsheep breeding.

Table 1. Lambing Performance of the First and Second Replicate Ewes when Lambing in January-February, 1974.

First Replicate

Breeding Group	No.[1] Exposed	Ewes Lambing No.	Ewes Lambing %	No. Lambs Born	Lambing Rate[2]	Lambs/Ewe Exposed
½D½R	22	21	95	40	1.90	1.82
¼D¾R	24	22	92	33	1.50	1.38
¼F¾R	0	0	0	0	0	0
¼F¼D½R	21	19	90	34	1.79	1.62
¼F½D¼R	21	21	100	34	1.62	1.62

Second Replicate

Breeding Group	No.[1] Exposed	Ewes Lambing No.	Ewes Lambing %	No. Lambs Born	Lambing Rate[2]	Lambs/Ewe Exposed
½D½R	19	19	100	30	1.57	1.57
¼D¾R	18	14	78	22	1.57	1.22
¼F¾R	27	24	89	35	1.46	1.29
¼F¼D½R	20	16	80	26	1.62	1.30
¼F½D¼R	17	12	71	20	1.67	1.18

[1] Ewes from two ram groups were deleted due to reproductive failure of the rams.
[2] Lambs born per ewe lambing.

Under Oklahoma conditions of generally abundant fall and early spring wheat pasture and mild winters, most commercial sheepmen have adopted a fall lambing program. Lambing at this time of year utilizes farm labor during one of the slower seasons of the year and takes advantage of the higher fat lamb prices in the spring of the year. With these considerations, the true test of the value of these five breeding groups of ewes to the commercial sheep industry of Oklahoma is their performance under a fall lambing program.

Table 2 presents the lambing performance of the five breeding groups when lambing in October-November, 1974. The first replicate ewes were approximately three and one-half years old and the second replicate ewes were approximately two and one-half years old. Lambs born per ewe exposed was poor for all breeding groups in both replicates. This is probably due in part to the fact that the majority of these ewes gave birth to and raised at least one lamb the previous winter. The ½D½R ewes produced more lambs per ewe exposed in both replicates than any other group as a result of a higher percentage of the ewes of this group lambing. In both replicates, the ¼ Finnsheep ewes containing some Dorset and Rambouillet breeding were not exceeded by any other group in lambing rate. Their poor performance was due to a large pro-

Table 2. Lambing Performance of the First and Second Replicate Ewes when Lambing in October-November, 1974.

First Replicate

Breeding Group	No. Exposed	Ewes Lambing		No. Lambs Born	Lambing Rate[1]	Lambs/Ewe Exposed
		No.	%			
½D½R	30	25	83	39	1.56	1.30
¼D¾R	33	24	73	33	1.38	1.00
¼F¾R	0	0	0	0	0	0
¼F¼D½R	26	19	73	31	1.63	1.19
¼F½D¼R	26	18	69	28	1.56	1.08

Second Replicate

Breeding Group	No. Exposed	Ewes Lambing		No. Lambs Born	Lambing Rate[1]	Lambs/Ewe Exposed
		No.	%			
½D½R	24	18	75	26	1.44	1.08
¼D¾R	23	17	74	21	1.24	0.91
¼F¾R	35	20	57	24	1.20	0.69
¼F¼D½R	25	13	52	19	1.46	0.76
¼F½D¼R	21	11	52	21	1.91	1.00

[1] Lambs born per ewe lambing.

portion of the ewes failing to lamb. The ¼F¾R ewes' poor lambing record was due to both a poor lambing rate and a large proportion of the ewes failing to lamb. A poor lambing rate for the ¼D¾R ewes is the main reason for their poor showing.

These preliminary data reveal the following tendencies of the five breeding groups when lambing in the fall:

1. The three breeding groups containing Finnsheep breeding do not readily conceive in the spring and, consequently, lamb in the fall when compared with the two groups containing only Rambouillet and Dorset breeding.
2. The two breeding groups containing the greatest proportion of Rambouillet breeding (¼F¾R and ¼D¾R) have the lowest lambing rates when compared with the other groups.
3. The two breeding groups containing Finnsheep, Dorset and Rambouillet breeding (¼F½D¼R and ¼F¼D½R) have the highest lambing rates.
4. The ½D½R breeding group has the greatest tendency to conceive in the spring and lamb in the fall.

These tendencies of the five breeding groups are based on only one fall lambing and under rather unusual conditions in that the ewes were also given an opportunity to lamb the previous winter. More data on the performance of these five breeding groups under fall lambing conditions will be gathered before definite conclusions as to their performance will be developed.

Fleece Characteristics

In April, 1974, the ewes of all five breeding groups were shorn, their grease fleeces weighed and the pounds of clean wool per fleece estimated. The fleeces were sent to the Midwest Wool Marketing Cooperative, Hutchinson, Kansas where they were graded by their staff. Table 3 presents the fleece data collected on the five breeding groups.

Table 3. Fleece Characteristics of the Five Breeding Groups Determined from the 1974 Clip.

Breeding Group	No.	Fleece Weight (lb.) Grease	Fleece Weight (lb.) Est. Clean	Grade[1]
½D½R	54	9.7	5.1	2.9
¼D¾R	57	10.4	5.4	2.3
¼F¾R	36	10.1	5.2	2.3
¼F¼D½R	52	10.0	5.0	3.1
¼F½D¼R	47	8.6	4.6	3.5

[1] Fleece Grade Code 1 = Fine, 2 = Half Blood, 3 = Three-Eights Blood, 4 = Quarter Blood.

The $\frac{1}{4}$D$\frac{3}{4}$R and $\frac{1}{4}$F$\frac{3}{4}$R ewes produced the heaviest grease fleeces, the $\frac{1}{4}$F$\frac{1}{4}$D$\frac{1}{2}$R and $\frac{1}{2}$D$\frac{1}{2}$R ewes produced the next heaviest fleeces and the $\frac{1}{4}$F$\frac{1}{2}$D$\frac{1}{4}$R ewes produced the lightest fleeces. These findings are a reflection of the fact that Rambouillets produce heavier fleeces than either Dorsets or Finnsheep.

Fleece grades followed a similar pattern with the fleeces from the $\frac{1}{4}$D$\frac{3}{4}$R and $\frac{1}{4}$F$\frac{3}{4}$R averaging slightly lower than "Half Blood". The fleeces from the $\frac{1}{4}$F$\frac{1}{4}$D$\frac{1}{2}$R and $\frac{1}{2}$D$\frac{1}{2}$R ewes averaged about "Three-Eights Blood" and the average grade of the fleeces from the $\frac{1}{4}$F$\frac{1}{2}$D$\frac{1}{4}$R ewes was intermediate between "Three-Eights" and "Quarter Blood".

These data would indicate that the substitution of a $\frac{1}{4}$ Finnsheep breeding for $\frac{1}{4}$ Dorset breeding in these crossbred ewes has little effect on grease fleece weight or grade.

Comparisons of Some Reproductive Traits of Dorset, Suffolk and Hampshire Rams Under Commercial Conditions

Joe V. Whiteman and L. Dwayne Flinn

Story in Brief

In order to get some information about breed of sire effects on certain reproductive traits, the records of the Ft. Reno flock for a 10 year period were studied. During this period 27 Dorset and 28 Blackfaced (about half were Suffolk and half Hampshire) rams were involved in 2501 matings and 2141 lambings. For certain comparisons the Blackfaced rams were compared to the Dorsets and for other studies the breed effects were studied by breed.

When the breeding season was during the spring, the Dorset rams were more aggressive whereas the Blackfaced rams were more aggressive during the late summer and fall. There was little difference due to ram breed in conception rate. When Dorset X Western crossbred ewes were mated to Blackfaced rams, they produced and reared nine more lambs per 100 ewes lambing than when mated to Dorset rams. Blackfaced rams

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sired more lambs that were born dead or died during lambing. Dorset sired lambs were about one-half pound lighter at birth and were more often born unassisted. Hampshire sired lambs were more often assisted and more often scored weak at birth.

Some of these breed differences were so small that other more important characteristics might well be the basis for deciding which breed of sire to use under specific conditions.

Introduction

Sheepmen seldom use enough rams of different breeds at one time or maintain the kind of records necessary to adequately evaluate the performance of rams of different breeds. Also, there is a great deal of variation between the performances of rams of the same breed. As a consequence of these conditions and others, there is a lack of information about the comparative performance of rams of the commonly used breeds.

The experimental flock at the Ft. Reno Livestock Research Station near El Reno has been managed under conditions similar to commercial production and has produced the kind of records that will permit certain kinds of breed comparisons relative to ram performance. The purpose of this paper is to summarize those results that are thought to be unbiased and of significance to sheepmen.

Materials and Methods

During the period 1960 through 1970 several breeding studies were underway with the flock. The mating plan involved comparing ewe breed and crossbred groups. The different mating pens were made up to contain equal representations of the different breeds and ages of ewes. The rams used were Dorsets, Suffolks or Hampshires. To each ewe pen one Dorset and one Blackfaced ram were assigned and each ram had an equal opportunity to make matings and sire lambs. The ewes in each pen were a mixture of Westerns (mostly Rambouillets) and Dorset X Western crossbreds in about equal proportions.

The rams of all breeds were commercial quality individuals with no special efforts made to select for or against any particular characteristics. Semen samples were collected by electroejaculation before the breeding season and only males with satisfactory semen were used. Marking harnesses and observations were also sources of information relative to ram performance. The records of rams that sired less than six lambs were not used.

During this period the mating seasons were sometimes during late May-June (spring) or during August-September or October-November (late summer and fall). During the mating season the two rams assigned to a mating pen were rotated daily if 25-35 ewes were involved or both rams were put in if pens contained larger numbers. During the periods of most rapid mating the rams were with the ewes from about 5:00 p.m. until 8:00 a.m. daily and were fed and rested during the day. Mating marks were recorded each morning to monitor the mating behavior of both rams and ewes.

Lambing was under rather close observation and ewes with difficulty were given assistance. Lambing records included birth weight of lamb(s), birth difficulty, lamb vigor and lamb livability. Also, at lambing the face color of the lamb indicated which of the rams sired the lamb.

During the period of the study, there were 55 different rams (27 Dorsets and 28 Blackfaces) used. The Dorset rams produced 98 ram season records. The 28 Blackfaced rams produced 99 ram seasons. The average age of rams used was almost identical indicating that the survival rate was similar and ram age did not effect the results.

Results

Because of the management of the flock during the years involved, it is felt that only certain of the possible comparisons are unbiased and produced dependable conclusions. Consequently, the results will be presented in that manner. The comparison of the Dorset to the Blackfaced rams is adequate for mating behavior, conception rate, lambing rate, lamb vigor and survival and lambing ease. The Hampshire and Suffolk sires can be compared only for lambing rate and difficulty and lamb vigor and survival.

Table 1 indicates that there were 2,368 ewe mating records that could be used in the study with 880 made during the fall and 1,488 made during

Table 1. The Number of Ewe Matings Recorded by Season and by Breed of Ram Making the First Mating.

Breeding season	No. of matings[1]	Breeding of ram	
		Dorset	Blackface
Fall	880	377	503
Spring	1488	792	696
Total	2368	1169	1199

[1] An additional 133 ewe matings resulted in twin born lambs with one lamb sired by the Dorset ram and one sired by the Blackfaced ram.

the spring. With the Dorset and Blackfaced rams given an equal opportunity to make the first mating, the Blackfaced rams made the first mating about 57 percent of the time under fall breeding conditions. This would suggest that the Blackfaced rams were more aggressive during the fall. On the other hand, under spring breeding conditions the Dorset rams made the first mating over 53 percent of the time and were more aggressive. Over all, the two kinds of rams were similar, but there does seem to be a seasonal difference in aggressiveness with Dorset rams excelling in the spring and Blackfaced rams excelling during the fall.

Table 2 presents the conception rate to the first mating for the two kinds of rams during the two seasons. Conception rate during the fall appears to be only slightly higher than during the spring. Likewise, conception rate to matings to Blackfaced rams appears to be slightly higher than to Dorsets. These differences are so small, however, that they could easily be due to chance and represent no real difference.

Table 3 presents the results that attempt to determine the advantage of mating Dorset X Western (DC) ewes to Blackfaced rams to produce triple cross (B X DC) lambs as compared to mating the same ewes to Dorset rams to produce backcross (D X DC) lambs.

In considering this comparison, it is important to remember that different mating plans were involved. When mated to Western ewes, both kinds of sires produced singlecross lambs that are thought to contain the normal amount of heterosis (hybrid vigor) for such traits as vigor and survival. When the two kinds of rams mated with the Dorset X Western crossbred ewes, the lambs from Dorset rams were backcross lambs while the lambs from the Blackfaced rams were triplecross lambs. It is expected that triplecross and singlecross lambs have heterosis in equal amounts while backcross lambs have only one-half as much. If there is heterosis for

Table 2. Numbers and Percentages of Ewes Conceiving to the First Mating for Each Breeding Season.

First Mating By	Breeding Season	Number Available	Number Conceived	Percent Conceived
Dorset rams	Spring	792	662	83.82
Dorset rams	Fall	377	332	85.41
		1169	985	84.30
Blackface rams	Spring	696	591	84.91
Blackface rams	Fall	503	432	85.88
		1199	1023	85.30

Table 3. Measures of Reproductive Performances of Dorset vs. Blackfaced Rams When Mated to Two Kinds of Ewes.

Measure	Kind of Mating				Triplecross[1] Advantage
	D X W	B X W	D X DC	B X DC	
No. ewes lambing	592	621	567	588	
Conc. to 1st Mating (%)	84.7	87.2	83.8	83.3	— 3.0
Lambing rate[2]	140.0	139.3	148.8	153.1	5.0
Lamb mortality[3]	7.1	9.9	7.9	7.4	— 3.3
Lambs reared[4]	130.1	125.4	137.0	141.7	9.4

[1] This compares triple cross (B X DC) to back cross (D X DC) using the single crosses (D X W and B X W) to correct for ram differences.
[2] Lambing rate is number of lambs born per 100 ewes conceiving to each kind of mating.
[3] Lamb mortality is lambs born dead or dying prior to two weeks of age as percent of total lambs born.
[4] Lambs reared is number of lambs alive at two weeks of age per 100 ewes lambing.

embryo survival and lamb liveability, we would expect to raise more lambs when Dorset X Western ewes conceive to Blackfaced rams than when they conceive to Dorset rams. The left two columns show the conception rates, lambing rates, % lamb mortality and lamb rearing rates when both Dorset and Blackfaced rams were mated to western ewes. There were slightly more lamb deaths from Blackfaced rams resulting in less lambs reared. The third and fourth columns give the results when the same rams were mated to Dorset X Western ewes. When comparing these values, we must realize that differences may be due to breed differences in the rams *or* to the difference in the heterosis of the lambs.

The last column is the difference in columns three and four adjusted by the differences shown in columns one and two. The —3.0 percent difference in conception to first mating in favor of the backcross mating could easily have been due to chance. The fact that it favors the backcross mating does not suggest any heterosis for the trait. The value of 5 more lambs born for triplecross than backcross matings results from a few more multiple births. This might be due to heterosis for embryo liveability. The difference in lamb mortality appears to be real, but is peculiar in that it suggests that these Blackfaced rams when mated to Western ewes produced lambs with a higher mortality than the Dorsets, but the higher mortality did not exist in matings with the crossbred ewes. The advantage of 9.4 lambs in lambs reared results from more lambs being born with a greater livability in Blackface by Dorset cross matings as compared to the backcross matings. This suggests that if sheepmen with Dorset X Western crossbred ewes will mate them to Blackfaced rams, they can expect to raise more lambs than if they are mated back to Dorset sires. Our best estimate of the advantage is about nine lambs per 100 ewes lambing.

If this 9.4 extra lambs reared per 100 ewes conceiving to this type of mating is an estimate of one-half of the heterosis involved in embryo and lamb livability, then the data suggest that heterosis could account for about 18 more lambs reared from crossbred matings as compared to straightbred matings. In any case, it strongly suggests the need for producing crossbred lambs when possible in commercial production.

Table 4 compares the three actual breeds of rams for these traits with the results averaged across the two kinds of ewes. It is first important to realize that there were no large differences found between the breeds of rams for these traits. Our experience indicates that the ram to ram variation within any one of these breeds is much greater than the average difference between breeds.

It is worth noting, however, that the Suffolks produced a few more multiple births than the other breeds, but if lambs surviving is the criteria of interest, the Dorset rams had a slight lead. This was partially due to less Dorset sired lambs that were born dead or died during birth. There were also less Dorset sired lambs that required assistance at birth. The latter would be expected because Dorset sired lambs average about one-half pounds less at birth than the Blackface sired lambs. According to our classification of vigor at birth, the Suffolk and Dorset sired lambs averaged a little higher than the Hampshire sired lambs, a few more of which had to be pulled.

Discussion

The traits considered in this study are important, but not the only traits concerned when deciding which breed of ram one should buy for commercial production. The fact that the breeds considered were so similar for the traits involved in this study suggests that it might be well to make major decisions on the basis of other traits.

Table 4. Comparison of Ram Breeds for Traits Involving Reproduction, Lambing Difficulty and Lamb Vigor.

Trait	Breed of Sire		
	Suffolk	Hampshire	Dorset
No. of ewes lambing	514	498	1159
Lambing rate[1]	147	144	144
Rearing rate[1]	132	130	133
Lambs born dead (%)[2]	4.3	3.9	2.4
Lambs born unassisted (%)	88	85	91
Lambs strong/birth[3] (%)	82	77	81

[1] Per 100 ewes lambing.
[2] Born dead or died during birth.
[3] A score given all newborn lambs.

Our past and continuing research results suggest that if sheepmen are going to save some of their ewe lambs for replacements and if they plan to lamb during the fall and early winter, the ram breed of choice is Dorset. Many years experience with hundreds of ewes indicate that the Dorset X Western crossbred ewe produces and raises more fall or early winter born lambs than any other breed or cross. Suffolk X Western ewes work satisfactorily for January-February lambing. If lambing during the spring, a crossbred ewe of any two productive breeds would be expected to produce more lambs than srtaightbred ewes, especially if the latter were Rambouillets that do not produce a high percentage of multiple births.

If a sheepman has followed a good plan and most of his ewes are good crossbreds, he should use rams of an unrelated breed that sire fast growing lambs with good carcasses. Although not included in this study, other studies from the Ft. Reno flock have shown that Blackfaced sires produce lambs that grow a little faster, especially after weaning at about 10 weeks of age, as compared to Dorset sired market lambs.

This study further emphasizes the fact that for commercial fall lambing conditions in Oklahoma, the most efficient use of breeds would involve mating Dorset rams to Rambouillet ewes to produce crossbred Dorset X Rambouillet ewe lambs to be kept for flock replacements. These crossbred ewes will be more productive than the Rambouillet ewes that produced them. This study suggests that the crossbred ewes will produce and raise more lambs if mated to Blackfaced (Hampshire or Suffolk) rams than if mated to Dorset rams.

Poultry

Improving Phytate Phosphorus Utilization by Poultry With Live Yeast Culture

Rollin H. Thayer and C. Dean Jackson

Story in Brief

Two feeding trials were conducted to determine the effect of a live yeast culture on phosphorus utilization in rations for growing chickens up to eight weeks of age. The total available phosphorus level of the grower ration was calculated first, and the amount of supplemental inorganic phosphorus needed to bring the total available dietary phosphorus level up to NRC Requirements was determined by difference. The amount of inorganic phosphorus supplement required to provide this amount was designated as 100 percent. The five other supplemental levels which were used were 0, 20, 40, 60, and 80 percent of this amount, respectively. These six dietary phosphorus levels were fed in one series of rations which contained a live yeast culture, and in another series of rations which did not.

Growth rate, units of feed per unit of gain, percent bone ash, percent bone calcium, and percent bone phosphorus were used to measure the efficiency with which the phosphorus was utilized. The live yeast culture produced a statistically significant increase in growth rate at inorganic phosphorus supplement levels of 0 and 20 percent of the amount required to meet NRC Requirements. Values for bone ash, bone calcium, and bone phosphorus for the growing chickens fed rations supplemented with live yeast culture, and those fed unsupplemented rations did not show statistically significant differences at these inorganic phosphorus supplement levels. However, substantial differences were evident and higher values were obtained with the growing chickens fed the live yeast culture.

Apparently the live yeast culture is bringing about a more efficient utilization of dietary phosphorus through the synthesis in the digestive tract of phytase which is hydrolyzing the phytate phosphorus. Based upon these data, it can be recommended that inorganic phosphorus supplement levels in a soybean oil meal—corn ration may be reduced by some 40 to 60 percent through the use of a live yeast culture without adversely affecting growth rate, efficiency of feed utilization, or bone ash percentage.

Introduction

Phytate phosphorus, the calcium-magnesium-potassium salt of phytic acid, is the organic form in which a major part of the phosphorus in plants is found. The phosphorus in alfalfa leaf meal, the cereal grains, soybean oil meal, cottonseed meal, and other feed ingredients manufactured from plants is present in this form.

In order for phytate phosphorus to be absorbed through the intestinal wall and utilized in bone formation or other physiological functions, it first must be changed by a chemical reaction into inorganic phosphate. This chemical reaction which is called hydrolysis is brought about by the action of the enzyme, phytase.

Phytase may be present in feed ingredients or can be produced by microorganisms in the digestive tract of domestic animals. If the concentration of phytase from these sources is sufficient, large quantities of phytate phosphorus will be hydrolyzed and the phosphorus utilized efficiently. It is possible also to hydrolyze the phytate phosphorus in plant feed ingredients during the manufacturing process through the use of molds which produce phytase.

Ruminants can utilize phytase phosphorus effectively since the microorganisms in the rumen produce adequate quantities of phytase. Thus, in this way, phytate phosphorus makes a major contribution to the readily utilizable dietary phosphorus in practical rations for beef cattle, dairy cattle, and sheep through the synthesis of phytase in the intestinal tract. On the other hand, simple stomach animals like swine, and poultry are not capable of producing phytase by this means, and for this reason, utilize phytate phosphorus very poorly or not at all. However, if phytase could be supplied by the addition of a feed ingredient with a high phytase content or by the addition of a feed ingredient which would promote the production of phytase, greater quantities of phytate phosphorus might be utilized.

During the current shortage of inorganic phosphorus supplements, feeding trials were initiated with growing chickens to determine if live yeast culture at a ration level of 2.5 percent would substantially increase phytate phosphorus utilization through the production of phytase in the intestinal tract. If this could be accomplished, the amount of supplemental inorganic phosphorus in a ration could be materially reduced without adversely affecting growth rate or bone formation. In addition, available supplies of inorganic phosphorus supplements would be conserved, and ration cost could be reduced.

Materials and Methods

Phytase Activity Invitro —

Whole corn at a normal moisture level was ground to pass a 1.5 millimeter screen in a Raymond Mill. Ninety parts of the ground corn were mixed with 10 parts of a live yeast culture and the whole blended for 2 hours in a Patterson-Kelly V-mixer to insure a uniform composition. An intensifier bar was used intermittently to insure mixing. Samples were taken for an analysis to determine total phosphorus and phytate bound phosphorus.

A fermentation mixture was prepared as a 20 percent solids slurry and adjusted to a pH of 5.0 with hydrochloric acid. Portions were added to sterile jars and incubated at 100° F for the fermentation phase of the reaction. Samples were taken at fermentation time intervals of 0, 0.5, 1.0, 4.0, and 24 hours and analyzed for phytate phosphorus.

Feeding Trial I —

Single Comb White Leghorn cockerels were used in Feeding Trial I. They were obtained when they were day-old and divided into 24 lots with 10 cockerels in each lot. Each lot was housed in a section of an electric battery brooder. Feed and water were provided *ad libitum*.

Each of the 12 exprimental rations as listed in Table 1 were fed to duplicate lots during a 3-week feeding period. The experimental rations were formulated to contain 6 graded levels of an inorganic phosphorus supplement (calcium 17.66 percent; phosphorus 18.25 percent by analysis) which supplied 0, 20, 40, 60, 80 and 100 percent, respectively, of the inorganic phosphorus supplement required to increase total available dietary phosphorus to a level equivalent to NRC Requirements. One series of 6 experimental rations formulated in this way was supplemented with 2.5 percent of a live yeast culture, and another series of 6 experimental rations had the live yeast culture replaced with ground yellow corn.

Individual body weights were taken at weekly intervals and feed consumption by lots was determined at the same time intervals. Tibia bones were taken at the end of the 3-week feeding period, and analyzed for percent bone ash, calcium, and phosphorus.

Feeding Trial II

Cornish X White Rock broilers were used in Feeding Trial II. At day-old they were distributed at random into 24 floor pens with 10 males and 10 females in each pen. Feed and water were provided *ad libitum*.

The 12 experimental rations as listed in Table 1 were fed to duplicate pens of broilers during the first 4 weeks of an 8-week feeding period. These are the same rations which were fed in Feeding Trial I during the

Table 1 - Experimental Rations

Ingredients	Ration Number (Percent)					
	1	2	3	4	5	6
Tallow (Feed Grade)	3.0	3.0	3.0	3.0	3.0	3.0
Ground Yellow Corn	49.12	49.12	49.12	49.12	49.12	49.12
Soybean Oil Meal (44%)	40.5	40.5	40.5	40.5	40.5	40.5
Live Yeast Culture[1]	2.5	2.5	2.5	2.5	2.5	2.5
dl Methionine	0.08	0.08	0.08	0.08	0.08	0.08
Inorganic Phosphorus Supplement (17.66% Ca-18.25% P)	0.00	0.55	1.09	1.64	2.18	2.73
Calcium Carbonate	2.43	2.26	1.99	1.71	1.44	1.16
Salt	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin Mineral Concentrate	0.5	0.5	0.5	0.5	0.5	0.5
Sand	1.37	0.99	0.72	0.45	0.18	0.00

Ingredients	Ration Number					
	7	8	9	10	11	12
Tallow (Feed Grade)	3.0	3.0	3.0	3.0	3.0	3.0
Ground Yellow Corn	51.62	51.62	51.62	51.62	51.62	51.53
Soybean Oil Meal (44%)	40.5	40.5	40.5	40.5	40.5	40.5
dl Methionine	0.08	0.08	0.08	0.08	0.08	0.08
Inorganic Phosphorus Supplement (17.66% Ca-18.25% P)	0.00	0.55	1.09	1.64	2.18	2.73
Calcium Carbonate	2.43	2.26	1.99	1.71	1.44	1.16
Salt	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin Mineral Concentrate	0.5	0.5	0.5	0.5	0.5	0.5
Sand	1.37	0.99	0.72	0.45	0.18	0.00

By Chemical Analysis Crude protein of the 12 rations ranged from 22.00 percent to 24.75 percent with an average of 23.37 percent. Total calcium of the 12 rations ranged from 0.82 percent to 1.28 percent with an average of 1.05 percent. Total phosphorus was 0.47, 0.57, 0.64, 0.73, 0.80, and 0.93 percent for Rations 1, 2, 3, 4, 5, and 6; and 7, 8, 9, 10, 11, and 12, respectively.

By Calculation: Comparable available phosphorus levels were 0.14, 0.24, 0.34, 0.44, 0.54, and 0.64, respectively.

[1] Manufactured by Diamond V Mills, Cedar Rapids, Iowa.

entire 3-week feeding period. These 12 experimental rations were modified in energy content by increasing the calorie to protein ratio at the beginning of the fifth and seventh weeks of the growing period in order to meet changing energy and protein intake requirements.

Individual body weights were taken at weekly intervals and feed consumption was recorded by pens at the same time intervals. Tibia bones were taken at the end of the fourth and eighth weeks of the growing period.

Appropriate statistical analyses were made on the data from both Feeding Trial I, and Feeding Trial II. The following responses were involved in these analyses: body weight, units of feed per unit of gain, percent of bone ash, percent bone calcium, and percent bone phosphorus.

Results and Discussion

Phytase Activity Invitro —

The rate at which the phytate phosphorus in the fermentation mixture was hydrolyzed by the live yeast culture is shown in Table 2. These data would indicate that 75 to 80 percent of the phytate phosphorus was released in four hours under the conditions of this test. All of the phytate phosphorus was released at some point between 4 and 24 hours after fermentation was initiated. Apparently a substantial amount of phytase was being produced by the live yeast culture and this enzyme was effective in hydrolyzing the phytate phosphorus present in the yellow corn. It is logical to conclude that this action might take place in a similar manner in the intestinal tract of growing chickens if the live yeast culture were included in the ration.

Feeding Trial 1 —

Body weight and feed conversion data for Feeding Trial 1 are presented in Table 3. There are statistically significant differences in average body weight in favor of the growing chickens fed the rations supplemented with the live yeast culture. The greatest growth response was made with inorganic phosphorus supplement levels of 0 and 20 percent of the required amount. However, there seemed to be some response in-so-far as growth rate was concerned irrespective of inorganic phosphorus supplement level. Growth rate was not fully compensated for at the lower phosphorus supplement levels since there are statistically significant differences due to inorganic phosphorus supplement level.

This advantage appears to increase from week to week. This may be due to the time lag required for the live yeast culture to establish itself

Table 2 - Rate of Phytate Hydrolysis by Live Yeast Culture Invitro[1]

Fermentation Time	Phytate Phosphorus in Fermentation Mixture by Iron Analysis	by Phosphorus Analysis
0.0 Hours	0.34 mg/gm	0.38 mg/gm
0.5 Hours	0.31	0.39
1.0 Hours	0.33	0.31
4.0 Hours	0.13	0.08
24.0 Hours	0.00	0.00

By Chemical Analysis — Total Phosphorus in Dry Mixture ---------- 3.25 mg/gm
Total Phosphorus in Fermentation Mixture (20 percent solids) -------- 0.70 mg/gm
Total Phytate Bound Phosphorus in Fermentation Mixture -------- 0.38 mg/gm

[1] Test conducted by Bedford Laboratories, Cedar Rapids, Iowa under the Supervision of Charlie Stone, Diamond V Mills, Cedar Rapids, Iowa.

Table 3 - Data Feeding Trial 1

Experimental Ration Number	Inorganic Phosphorus Supplement Level (Percent Required Amount)	Live Yeast Culture (Percent of Ration)	WEEKS 1 Body Wt (gm)	WEEKS 1 Units Feed / Unit Gain	WEEKS 2 Body Wt (gm)	WEEKS 2 Units Feed / Unit Gain	WEEKS 3 Body Wt (gm)	WEEKS 3 Units Feed / Unit Gain
1	0	2.5	57	2.48	106	3.28	179	2.13
2	20	2.5	59	2.11	115	2.70	200	2.33
3	40	2.5	63	2.30	135	2.20	237	1.94
4	60	2.5	68	2.27	151	2.46	255	1.81
5	80	2.5	65	2.43	148	2.16	253	1.97
6	100	2.5	65	2.18	142	2.36	242	1.95
7	0	0	58	2.59	111	2.61	165	3.87
8	20	0	60	2.65	117	2.82	200	2.46
9	40	0	61	2.20	128	2.71	223	2.17
10	60	0	69	1.81	147	1.96	251	1.87
11	80	0	65	2.05	144	2.39	247	2.01
12	100	0	66	1.85	140	2.43	243	1.80
		Experimental Ration:						
Difference Between Live Yeast Culture and No Yeast Culture		1 minus 7	−1		−5		+14	
		2 minus 8	−1		−2		0	
		3 minus 9	+2		+7		+14	
		4 minus 10	−1		+4		+ 4	
		5 minus 11	0		+4		+ 6	
		6 minus 12	+1		+2		− 1	

in the intestinal tract. A similar trend can be noted in Feeding Trial 2. There are no statistically significant differences in efficiency of feed conversion in Feeding Trial 1.

A statistical analysis of the bone ash, bone calcium, and bone phosphorus data does not show any statistically significant differences (Table 4.) Nevertheless, there are obvious differences in favor of the growing chickens fed the live yeast culture. This would indicate that phosphorus utilization is being enhanced by the action of the live yeast culture.

Feeding Trial 2 –

Body weight and feed conversion data for Feeding Trial 2 are given in Table 5 for weeks 1 through 4, and in Table 6 for weeks 5 through 8. Results are similar to those obtained in Feeding Trial 1. The trends which were apparent during the 3-week feeding period in Feeding Trial 1 persisted during the entire 8-week feeding period in Feeding Trial 2. Statistically significant differences in average body weight were apparent between the chickens fed the rations supplemented with live yeast culture and those fed the unsupplemented rations. Again this difference was most pronounced at the inorganic phosphorus supplement levels of 0 and 20 percent of the required amount. It continued to widen as the feeding period progressed. There were no real differences in efficiency of feed conversion.

Table 4 - Data Feeding Trial 1 - Bone Ash, Bone Calcium, and Bone Phosphorus

Experimental Ration Number	Inorganic Phosphorus Supplement Level (Percent Required Amount)	Live Yeast Culture (Percent of Ration)	Bone Ash (Percent)	Bone Calcium (Percent)	Bone Phosphorus (Percent)
1	0	2.5	33.44	11.3	5.47
2	20	2.5	39.33	----	----
3	40	2.5	44.12	15.2	7.68
4	60	2.5	44.22	15.5	7.76
5	80	2.5	45.41	16.0	8.07
6	100	2.5	46.36	16.4	8.29
7	0	0	30.70	10.3	5.14
8	20	0	35.99	12.2	6.12
9	40	0	43.84	15.2	7.71
10	60	0	43.97	15.3	7.85
11	80	0	45.53	16.1	8.11
12	100	0	44.33	15.9	7.92

Table 5 - Data Feeding Table 2 - For Weeks One Through Four

Experimental Ration Number	Inorganic Phosphorus Supplement Level (Percent Required Amount)	Live Yeast Culture (Percent of Ration)	WEEKS							
			1		2		3		4	
			Body Wt (gm)	Units Feed / Unit Gain	Body Wt (gm)	Units Feed / Unit Gain	Body Wt (gm)	Units Feed / Unit Gain	Body Wt (gm)	Units Feed / Unit Gain
1	0	2.5	116	1.20	225	1.43	344	3.07	542	2.00
2	20	2.5	121	1.17	244	1.61	392	2.21	586	2.65
3	40	2.5	118	1.19	251	1.71	403	2.15	585	2.98
4	60	2.5	122	1.26	254	1.70	410	1.79	627	2.56
5	80	2.5	122	1.31	252	1.56	379	2.23	589	2.42
6	100	2.5	124	1.29	265	1.56	417	1.95	645	2.49
7	0	0	108	1.18	207	1.82	318	2.25	485	2.40
8	20	0	113	1.89	231	1.55	364	2.43	591	2.03
9	40	0	120	1.47	257	1.73	409	1.46	586	3.34
10	60	0	125	1.61	264	1.63	407	1.47	624	2.65
11	80	0	117	0.81	252	1.45	398	2.18	614	2.36
12	100	0	124	1.22	267	1.46	409	2.15	616	2.43
		Experimental Ration:								
Difference Between		1 minus 7	+8		+18		+26		+57	
Live Yeast Culture		2 minus 8	+8		+13		+28		− 5	
and No Yeast Culture		3 minus 9	−2		− 6		− 6		− 1	
		4 minus 10	−3		−10		+ 3		+ 3	
		5 minus 11	+5		0		−19		−25	
		6 minus 12	0		− 2		+ 8		+29	

Table 6 - Data Feeding Trial 2 - For Weeks Five Through Eight

Experimental Ration Number	Inorganic Phosphorus Supplement Level (Percent Required Amount)	Live Yeast Culture (Percent of Ration)	WEEKS 5 Body Wt (gm)	5 Units Feed / Unit Gain	6 Body Wt (gm)	6 Units Feed / Unit Gain	7 Body Wt (gm)	7 Units Feed / Unit Gain	8 Body Wt (gm)	8 Units Feed / Unit Gain
1	0	2.5	722	2.62	881	3.42	1042	3.44	1196	3.66
2	20	2.5	817	2.53	1018	2.97	1307	2.32	1623	2.46
3	40	2.5	847	2.05	1089	2.46	1363	2.65	1687	2.66
4	60	2.5	864	2.44	1070	2.97	1381	2.27	1681	2.68
5	80	2.5	829	2.31	1024	2.91	1313	2.36	1632	2.55
6	100	2.5	857	2.48	1043	3.15	1335	2.35	1642	2.50
7	0	0	633	2.91	785	3.75	898	4.82	1033	4.99
8	20	0	805	2.33	998	2.77	1204	2.75	1469	3.20
9	40	0	852	2.13	1045	3.46	1343	2.40	1660	2.56
10	60	0	887	2.17	1085	2.86	1397	2.37	1712	2.63
11	80	0	881	2.17	1088	2.86	1398	2.33	1692	2.86
12	100	0	893	2.02	1132	2.52	1401	2.97	1729	2.46
Difference Between Live Yeast Culture and No Yeast Culture		Experimental Ration:								
		1 minus 7	+89		+96		+144		+163	
		2 minus 8	+12		+20		+103		+154	
		3 minus 9	− 5		+44		+ 20		+ 27	
		4 minus 10	−23		−15		− 16		− 31	
		5 minus 11	−52		−64		− 85		− 60	
		6 minus 12	−36		−89		− 66		− 87	

The Relation of K^{40} Net Count and Probe to Body Composition Changes in Growing and Fattening Swine

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Story in Brief

This research was initiated to study the feasibility of using the K^{40} technique and live backfat probe to evaluate body composition changes in muscling in swine at different slaughter weights. A new K^{40} detector arrangement was used in this study in an attempt to improve counting efficiency for hogs ranging in weight from 100 to 300 pounds. The Duncan Lean Meter was used as the live backfat probe in the study.

One hundred barrows involving ten replications of ten feeder pigs each were randomly allotted to slaughter weight groups of 100, 150, 200, 250, and 300 pounds. From each replication, two pigs were randomly assigned to each slaughter weight group, making a total of 20 pigs (14 Hampshires and 6 Yorkshires) for each of five slaughter weights. Upon reaching the pre-determined slaughter weight, each pig was evaluated using the K^{40} technique and live backfat probe (Duncan Lean Meter) and transported to the O.S.U. Meat Laboratory for slaughter and carcass evaluation. Carcass measurements obtained included length, average backfat thickness, loin eye area, weight of ham, loin, and shoulder, weight of total fat trim, bone weight, and weight of boneless closely trimmed lean from the right carcass half. Ether-extract analyses were conducted on ground lean samples of the right carcass halves and total pounds of fat-free lean were determined.

The data yield very good estimates of the changes in measurements, counts and composition of the barrows as they developed from 100 to 300 pounds. It is also apparent that these were very muscular barrows that continued to grow more and fatten less than is typical of barrows generally after reaching usual market weights of about 225 pounds.

Five prediction equations involving live weight, K^{40} count, and live backfat probe as predictors were developed to estimate pounds of fat-free lean which accounted for from 98.1 to 77.6 percent of the variation in pounds of fat-free lean in the Yorkshires and from 96.3 to 77.9 percent in Hampshires, respectively. Live weight alone was associated with 96 percent of the variation in pounds of fat-free lean in the Yorkshires and 94.4 percent of the variation in the Hampshires. While the addition of net K^{40} count to the equation improved the predictive value of the equation, such improvement was relatively small.

Introduction

The search for an accurate method of estimating the composition of meat animals has resulted in the development and evaluation of various instruments designed for this purpose. Early attempts to estimate carcass composition generally consisted of the analysis of a small portion of the carcass such as loin eye area, certain bone and muscle relationships, or the actual physical dissection of the carcass, or a portion of its parts. Some of these methods are quite reliable predictors of carcass composition, but all were laborious, costly and require the slaughtering of animals. In more recent years, researchers have sought for more efficient ways of estimating body composition that would not require the sacrificing of animals. Two such methods that have been evaluated at the Oklahoma Agricultural Experiment Station are the O.S.U. K^{40} whole-body counter and the Duncan Lean Meter live backfat probe.

Previous research at the Oklahoma Station involving these two methods of evaluation were conducted using barrows that were uniform in age, breeding and weight. Results from these studies, primarily involving the K^{40} whole-body counter, have led to the development of prediction equations that are currently used to predict the muscle content of 220-240 pounds hogs.

The feasibility of using the K^{40} technique and live probe to predict muscling in younger, lighter weight hogs has been considered with the thought that considerable savings in time and expense could be achieved if prediction equations were available for such animals.

Materials and Methods

One hundred market barrows (70 Hampshires and 30 Yorkshires) were evaluated by the K^{40} whole-body counter and a live probe (Duncan Lean Meter) beginning in March, 1972, and ending in January, 1974. The barrows were obtained from the University purebred herds, weighing between 60 and 70 pounds each and were generally large framed, growthy, heavily muscled pigs.

Ten replications, each consisting of ten feeder pigs, were randomly assigned to slaughter weight groups of 100, 150, 200, 250, and 300 pounds and placed on a growing-fattening ration. From each replication, two pigs were randomly allotted to each slaughter weight group, making a total of 20 pigs in each of the five slaughter groups as shown in Table 1.

As the pigs reached the shrunk live weights of 100, 150, 200, 250, and 300 pounds, they were taken off-feed for 24 hours and thoroughly washed to remove any foreign materials that might influence the K^{40} count. The pigs were then probed at the first rib, last rib, and last lumbar vertebra with a Duncan Lean Meter.

The Duncan Lean Meter provided a rapid method for estimating the thickness of backfat. The method is based on the differences in electrical conductivity of fat and muscle; fat being a relatively poor conductor, while muscle is considered to be a good conductor by comparison.

After the pigs were probed, they were K^{40} counted in a randomized order. A new detector arrangement was used in counting these animals in an attempt to improve K^{40} counting efficiency over a range of live weights (100 to 300 pounds). In addition to a new detector arrangement, a method of positioning the pigs as close to the detector system as possible was devised. Those pigs in the light weight groups were evaluated in the counting chamber by placing one or more one-inch planks on the floor of the chamber in order to maintain the same distance between animals of different weights and the detectors.

Each barrow was evaluated twice on the same day by the K^{40} whole-body counter. This was done in an effort to determine the repeatability of the instrument. Correlation coefficients between the first and second net K^{40} counts are presented in Table 2. Values at each weight were found to be highly significant, indicating that the instrument was repeating itself reasonably well. The repeatability was not as high for the 100 pound weight groups as for the heavier weights.

Table 1. Experimental Design

Replication	Slaugher Weight Groups (pounds)				
	100	150	200	250	300
I	2[1]	2	2	2	2
$\bar{X}$	$\bar{2}$	$\bar{2}$	$\bar{2}$	$\bar{2}$	$\bar{2}$
Total	20[2]	20	20	20	20

[1] Number of animals per replication per weight group.
[2] Total number of animals per weight group.

Table 2. Correlation Coefficients Between First and Second Live K^{40} Net Counts (same animal)

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
No. of Animals	100	80	60	40	20
Correlation Coefficients	0.80**	0.92**	0.92**	0.95**	0.92**

Those barrows designated at the beginning of the experiment to be slaughtered at a particular weight were transported to the O.S.U. Meat Laboratory for slaughter and carcass composition evaluation. The carcass measurements obtained included length, average backfat thickness, loin eye area, weight of ham, loin, shoulder, total fat trim, bone, and weight of boneless closely trimmed lean from the right carcass half.

Chemical analyses for ether-extract were conducted in triplicate on samples representing the boneless, closely trimmed muscle mass from the right half of each carcass. Ether extraction was determined by a standard A.O.A.C. method. Fat-free lean was determined by subtracting total ether-extractable materials from the weight of the boneless, closely trimmed muscle mass from the right carcass half. This method has been shown to produce a very accurate measure of carcass leanness.

Results and Discussion

The data in Table 3 are presented as a description of the barrows from a carcass measurement and composition standpoint. Later reference will be made regarding the desirability of this set of barrows insofar as growth characteristics and muscling are concerned. Figure 1 is a graphic presentation of the rate of muscle growth by slaughter weight groups as determined by differences in amounts of fat-free lean between slaughter weights. It can be seen from this tabulation of the composition data that bone increased at a steady rate from 100 pounds through 300 pounds live weight. Fat tended to increase at a more rapid rate through the heavier weights, but at a distinctively slower rate than is generally found in market hogs, especially in weights above 200 pounds. Lean, on the other hand, normally increases at a much slower rate beyond 200 pounds live weight than was characteristic of these growthy and very meaty barrows, that continued to produce muscle at a faster rate than normal even up to 300 pounds live weight.

Means for K^{40} counts per minute and live probe for both Yorkshire

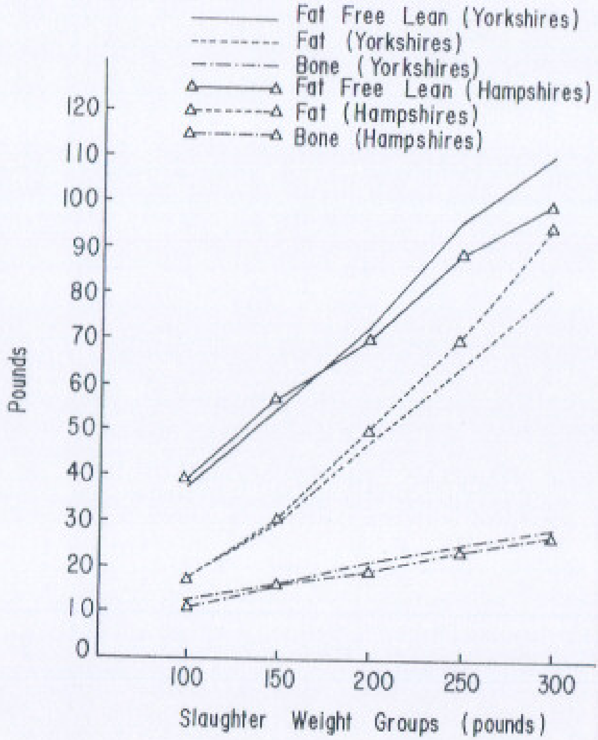

Figure 1. Mean pounds of fat-free lean, fat, and bone from Yorkshire and Hampshire barrows at five different weights.

and Hampshire pigs slaughtered at different weights are shown in Table 4.

As slaughter weight increased, net K^{40} count per minute increased for both breeds. The realtionship between net K^{40} count and slaughter weight is more clearly illustrated in Figure 2. A rather steady increase was observed for mean K^{40} counts per minute for the Yorkshires from 100 to 250 pounds with a slight decline in rate of increase occurring from 250 to 300 pounds. It appears that the steady increase for mean K^{40} count did not exist in the Hampshire data as in the Yorkshire data, especially from 250 to 300 pounds were only a moderate increase in K^{40} count was observed. The differences in net K^{40} count responses (especially from 250 to 300 pounds) indicate that there may have been some composition differences between the Hampshire and Yorkshire pigs representing the 300 pound slaughter group. While pounds of fat-free lean for the 100, 150 and 200 pound barrows were quite comparable in both breed groups,—

Table 3. Mean Carcass Measurements of Barrows at Different Weights

YORKSHIRES	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
Number of animals	6	6	6	6	6
Carcass weight, Lbs.	68.0	103.0	141.7	187.0	222.9
Dressing percent	67.4	69.2	72.4	74.1	74.3
Backfat, in.	0.62	0.93	1.14	1.26	1.28
Carcass length, in.	25.3	28.2	30.5	32.4	34.3
Loin eye area, sq. in.	2.62	3.75	4.49	5.35	6.18
Lean cuts, % car. wt.	62.6	61.1	58.7	59.0	57.3
Fat-free lean, lbs.	38.0	55.1	72.7	96.1	110.8
HAMPSHIRES					
Number of animals	14	14	14	14	14
Carcass weight, lbs.	68.5	104.4	141.0	184.6	223.2
Dressing percent	67.3	70.5	71.7	74.5	74.5
Backfat, in.	0.62	0.80	1.05	1.19	1.41
Carcass length, in.	24.8	27.8	29.7	31.7	33.2
Loin eye area, sq. in.	3.14	4.30	5.02	5.83	5.77
Lean cuts, % car. wt.	64.8	63.3	58.5	57.6	53.5
Fat-free lean, lbs.	39.2	56.9	70.2	89.2	100.5

Table 4. Mean Live Measurements For Yorkshire and Hampshire Barrows Slaughtered in Different Weights.

	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
YORKSHIRES (No.)	6	6	6	6	6
Slaughter wt., (lbs.)	100.8	148.7	195.8	252.2	300.2
K^{40} C.P.M., live	3641	4559	5253	6007	6494
Live Probe, in.	0.59	0.90	1.08	1.27	1.36
HAMPSHIRES (No.)	14	14	14	14	14
Slaughter wt., lbs.	101.7	148.1	196.8	247.7	299.6
K^{40} C.P.M., live	3747	4887	5187	6050	6171
Live Probe, in.	0.61	0.81	1.10	1.24	1.43

the 250 pound Yorkshires had 7 pounds more fat-free lean and at 300 pounds—over 10 pounds more (about 10 percent) fat-free lean than the Hampshire barrows (see Table 3).

As illustrated in Figure 2., the most rapid increase in net K^{40} count per minute for both breeds occurred between the 100 and 150 pound weights, while the slowest rate of increase in K^{40} net count occurred between the 250 and 300 pound weight interval for both breeds. The somewhat smaller increase in net K^{40} count from 250 to 300 pounds may have been due to the possible "shielding" effect of fat against the transmission

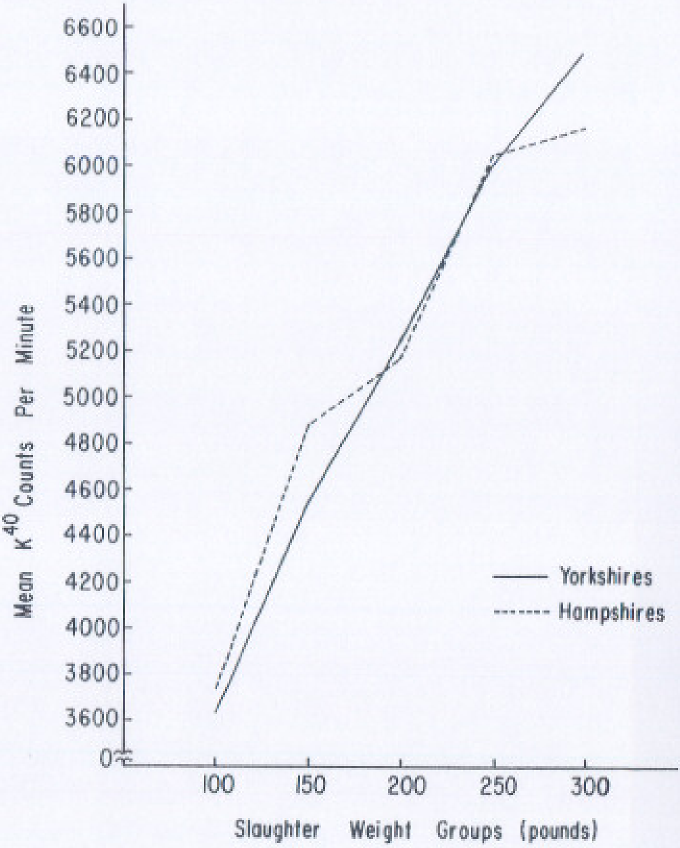

Figure 2. Mean K^{40} Counts per minute for Yorkshire and Hampshire barrows slaughtered at different weights.

of radiation energy from whole-body potassium which has been postulated by researchers in this field.

The average backfat thickness estimated by the live probe ranged from 0.59 to 1.36 inches for the Yorkshires and from 0.61 to 1.43 inches for the Hampshires (Table 4). Average increases in backfat probe for each 50 pound increase in live weight were 0.31, 0.18, 0.19, 0.09 inches for the Yorkshires and 0.20, 0.29, 0.14, and 0.19 inchs for the Hampshires. The increase in backfat probe with increased live weight was rather uniform in the Hampshire data. However, this was not the case in the Yorkshire data where the greatest increase in live probe occurred from 50 to 100 pounds, while the smallest increase occurred from 250 to 300 pounds.

One of the primary objectives in this study was that of the development of prediction equations for estimating pounds of fat-free lean in barrows weighing 100 and 300 pounds. Three live measurements (live weight, K^{40} count, and live probe) were made on each barrow prior to slaughter. A regression study was conducted on these estimates in an effort to determine their relationships with each other, as well as with fat-free lean, and to establish some prediction equations which would prove useful in estimating fat-free lean in pigs weighing between 100 and 300 pounds.

Linear prediction equations for fat-free lean are presented in Table 5 for the Yorkshires and Hampshires. Standard errors of estimate and coefficients of determination are also given for each regression equation. The standard error of estimate is the average amount by which one would miss the trait (pounds of fat-free lean) being predicted if he used the prediction equation indicated. In these data where the barrows were of five distinct weight groups, the use of weight as the only predictor was better than using either K^{40} count or live probe. The use of K^{40} count in combination with live weight predicted a little more accurately than using live probe with live weight (average miss of 3.9 vs. 5.3 or 4.5 vs. 5.4 lbs.)

When the data were studied within the weight groups to determine

Table 5. Linear Prediction Equations for Yorkshire and Hampshire Pigs Using K^{40} Count, Live Weight, and Live Probe

	Predicted Variable		Weight	K^{40} Count	Live Probe	Standard Error of Estimate[2]
YORKSHIRES	(30)					
	FFL[1]	−106.4	+2.98(WT)			5.67
	FFL	248.2		−0.20(CT)		8.71
	FFL	234.5			−838.99 (L.P.)	13.99
	FFL	−20.0	+0.25(WT)	+0.009(CT)		3.92
	FFL	4.2	+0.43(WT)		−13.96 (L.P.)	5.29
HAMPSHIRES	(70)					
	FFL	−138.8	+3.72(WT)			5.55
	FFL	−568.1		+0.49(CT)		8.33
	FFL	50.5			−141.57 (L.P.)	11.04
	FFL	−12.5	+0.22(WT)	+0.008(CT)		4.46
	FFL	13.1	+0.39(WT)		−18.29 (L.P.)	5.41

[1] FFL=Predicted pounds of fat-free lean.
[2] Average amount by which predicted value would be expected to miss the actual pounds of fat-free lean.

how well fat-free lean could be predicted on that basis from K^{40} count and/or live probe, it was found that the results were too inconsistent for interpretation. This was due to small numbers in each breed at each weight and to the lower relationships between K^{40} count and live probe with carcass composition measures when the barrows were essentially of the same size.

The value of an insturment such as the K^{40} whole-body counter or Duncan Lean Meter depends upon its ability to improve the accuracy with which we make predictions. Results of this study indicated that live weight alone removed 96.3 percent of the variation when predicting fat-free lean in the Yorkshires and 94.4 percent of the variation in the Hampshires. When K^{40} count was placed in the regression equation, 91.3 percent of the variation in predicting fat-free lean was accounted for in the Yorkshires, while the value was 87.4 percent in the Hampshires. The live backfat probe estimate contributed the least insofar as removing variation in estimating fat-free lean (77.6 percent in the Yorkshires and 77.9 percent in the Hampshires).

The prediction value of "live weight" for muscling in very muscular hogs that are continuing to develop muscling at a rapid rate at what to some may appear to be a "heavy" weight (300#) is not totally unexpected. Figure 2 illustrates the point that both the Yorkshire and Hampshire barrows had only very slightly retarded their rate of fat-free lean development at 300 pounds. As muscle storage diminishes and body fat stores accumulate, which is characteristic with meat animals on feed as they reach mature body weight, then body weight is expected to become of lesser value as a predictor of fat-free lean in the body.

Metabolic Indices of Bovine Muscle Growth

J.R. Escoubas, J.J. Guenther and K.K. Novotny

Story in Brief

Eight month and twelve month Hereford steer calves were used to initiate an investigation of metabolic growth patterns in the bovine. Tissue samples were obtained from the left Longissimus dorsi muscle immediately postmortem and extracted in the fresh state. Various key oxidative and glycolytic enymes were assayed and the data expressed in specific activity units per gram of protein. Results indicate an increasing trend in glycolytic metabolic activity, a concomitant decrease in the specific activity of enzymes associated with oxidative metabolism, and elevated activities of an enzyme associated with nucleic acid biosynthesis.

Increased activities of a key enzyme associated with fatty acid oxidation were noted with increasing age. These data are preliminary but suggest a metabolic adaptation from a muscle system of predominately red type fibers (eight month old calves) to a muscle system of less predominately red type fibers (twelve month old calves). This adaptation appears to parallel elevated protein synthesis resulting in muscular hypertrophy. Further work is continuing to elucidate these findings.

Introduction

It has been demonstrated that, postnatally, muscle tissue undergoes a cellular, motoneural controlled differentiation which results in the production of red, white and/or intermediate fibers with the red type rich in oxidative enzymes, the white type rich in glycolytic enzymes and the intermediate type having similar oxidative and glycolytic enzymic properties. Since the environment as well as genetics directly affects motoneural innervation and ensuing protein synthesis, an investigator may feasibly monitor muscle metabolic and protein synthesis trends and simultaneously impose specific environmental treatments such that these trends and their changes due to imposed treatments might be indexed. Thus, in order to obtain this information on the bovine, indepth studies must be accomplished on animals of differing sizes and when subjected to differing nutritional and environmental conditions.

Materials and Methods

To initiate a metabolic investigation on bovine muscle tissue, various enzymes were assayed and included those as outlined in Table 1. For this study, muscle tissue was obtained from the left longissimus dorsi in the 13th thoracic region from 500 and 700 pound Hereford steers averaging eight months and twelve months age, respectively. Muscle samples were excised immediately after rapid skinning and chilled promptly in ice. The tissue was then transported to the laboratory for extraction and subsequent enzyme assays. The muscle tissue was extracted in buffered sucrose, using the glass-teflon Potter-Elvejhem apparatus for homogenization, centrifuged and th supernatant obtained utilized as the source for all cell soluble enzymes and the precipitate obtained resuspended in sucrose media and recentrifuged. The mitochondrial pellet obtained from the final centrifugation was again suspended in sucrose media and used as the source of aerobic enzyme analyses.

All enzyme assays were performed on appropriate dilutions of the specific muscle extract. All assays except that for succinate oxidase were made in quartz cuvettes using a Gilford Model 240 spectrophotometer with necessary attachments and maintaining an assay environment of 37° C. Succinate oxidase was determined via the YSI Model 53 Biological Oxygen Monitor System.

Results

The data as reflected in Table 1 suggest an increasing trend in glycolytic metabolism between the cattle contained in the two weight groups. This increase in enzyme activity as evidenced from both glyceraldehyde-3-phosphate dehydrogenase and lactate dehydrogenase could be the result of a cellular adaptation from the predominately red type fiber rich in oxidative enzymes to a muscle cell type less predominate in red fibers and having an increasing quantity of white type fibers. This reasoning is also evidenced in the decreasing trends of the oxidative enzymes malate (NAD) dehydrogenase, succinate dehydrogenase and citrate synthetase. These results coincide favorable with the work of Bass *et al* (1965) in rabbits. It is also interesting to note that total oxygen consumed, reflected as succinate oxidase activityy (Burleigh *et al*, 1969), decreased as the animals aged, indicating simply that total oxidative capacity decreased whether by a decrease in functionality of the mitochondria (Sacktor, 1972), a decrease in number of mitochondria or a "diluting" of the existing mitochondria resulting from fiber hypertrophy (Gauthier, 1970). Irrespective of the exact mechanism, the data in Table 1 suggests a loss of activity of the mitochondrial associated enzymes and an increase in activity of the

Table 1. Average enzyme activities[1] of Hereford steers at two weight groups.

	500 lb.	700 lb.
Lactate Dehydrogenase	314.0	321.0
Glyceraldehyde-3-Phosphate Dehydrogenase	2.08	2.27
Glucose-6-Phosphate Dehydrogenase	0.01	0.03
Malate Dehydrogenase (NAD)	4.14	1.12
Succinate Dehydrogenase	62.5	11.7
Citrate Synthetase	3.40	1.76
β-Hydroxy Acyl CoA Dehydrogenase	1.52	1.80
Succinate Oxidase[2]	3.30	1.02

[1] Enzyme activities expressed as Units of enzyme activity per gram of protein per gram of tissue.
[2] Activity expressed as M Oxygen consumed per minute per gram of protein per gram of tissue.

cell soluble enzymes corrected for protein concentration and the amount of tissue used.

Even though the data suggest a decreasing trend of oxidative metabolism, the activity of β-hydroxyacyl CoA dehydrogenase, a key enzyme of fatty acid oxidation, depicts an increase in its specific activity with increasing age of the cattle. This might indicate that although oxdative metabolism decreases with age, there appears to be an increasing capacity for utilizing energy substrates for mitochondrial oxidation from fatty acid sources (Annison, 1964). The present study also indicates an increasing trend in the activity of glucose-6-phosphate dehydrogenase with age, which has a commonly accepted function of generating reduced nucleotide phosphate cofactors for use in fatty acid biosynthesis. This increase in fatty acid biosynthesis with concomitant increases in fatty acid oxidation would not be acceptable, yet one must realize that the pentose phosphate pathway is also of primary importance in nucleotide and nucleic acid biosynthesis. Nuclotide biosynthesis would be necessary for RNA synthesis and subsequent protein synthesis. Thus, accretions in the specific activities of glucose-6-phosphate dehydrogenase might indicate an increasing trend of protein deposition when taking other enzyme systems into consideration.

These data are preliminary yet they correspond well with past investigations as noted above. It is expected that in continuing research, more detailed metabolic and protein synthsis patterns be investigated in order to shed more light on growth patterns and methods of controlling these patterns in beef cattle.

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Muscle Fiber Growth of Cattle Differing in Mature Size

J.J. Guenther and J.R. Escoubas

Story in Brief

Changes in muscle fiber diameter of small and large scale beef calves were determined. Fiber diameters were measured, initially, when the calves were approximately 30 days of age and at 56 day intervals thereafter until the calves were about 14 months of age. Results showed the small scale calves to have wider muscle fibers than large scale calves and that the small scale calves matured earlier and at a faster rate in fiber diameter. In addition, most of the absolute increase in muscle fiber diameter occurred post-weaning. Finally, it was observed that at 30 days of age the test animals had already attained 46-47 percent of their respective 14 month muscle fiber diameter.

Introduction

In the cattle business, muscle is the ultimate product. Typically, beef carcasses consist of approximately fifty "principal" muscles. Perhaps the best known of these is the longissimus dorsi or "Ribeye". This muscle is also the single, largest "quality" muscle in the beef carcass. Hence it is often selected as the target for various muscle research studies.

A particular muscle is composed of a given number of sub-units called muscle fibers, which are actually the "cells" of the muscle. These cells or fibers are the functional units of the muscle and thus it might be assumed that as the individual fibers grow, so grows the entire muscle. An increase in muscl size, then, is brought about by an increase in the size of its sub-units, the fibers.

It is generally accepted that at birth the total number of muscle fibers is pretty much set in the bovine and that very few, if any, addition fibers are "laid down" post-natally. Consequently the subsequent increase in muscle size during pre- and post-weaning growth and development of the beef calf might be followed by studying various changes in individual muscle fiber parameters, such as fiber diameter. The objective of this study was to assess changes in muscle fiber diameter occurring during growth and development of cattle of differing size and weight.

Materials and Methods

Experimental units for the study were eight Angus and eight Charolais steer calves. These calves were selected to represent small and large scale cattle, respectively. At test period one, the calves averaged one month of age. At weaning, which was test period four, they averaged seven months and at the final test period, number eight, they averaged fourteen months. Test Period intervals were fifty-six days. At each period biopsy samples were obtained from the left and right longissimus dorsi muscles of each experimental calf. Muscle fiber diameter was determined on the biopsy samples following procedures developed in this laboratory and reported previously.

Results and Discussion

Experimental results are shown in Figures 1 and 2. In Figure 1 the data are presented on an absolute basis; whereas in Figure 2 they are given as a percentage of the final test period value. This is why the period 8 values in Figure 2 are shown as 100 percent. Each value shown in Figure 1 represents the average diameter of fifty muscle fibers.

The small scale Angus calves were greater in fiber diameter than the

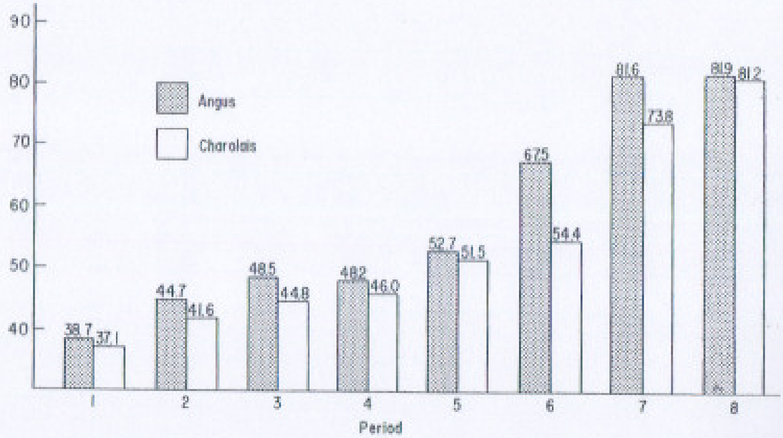

Figure 1. Fiber diameter - microns.

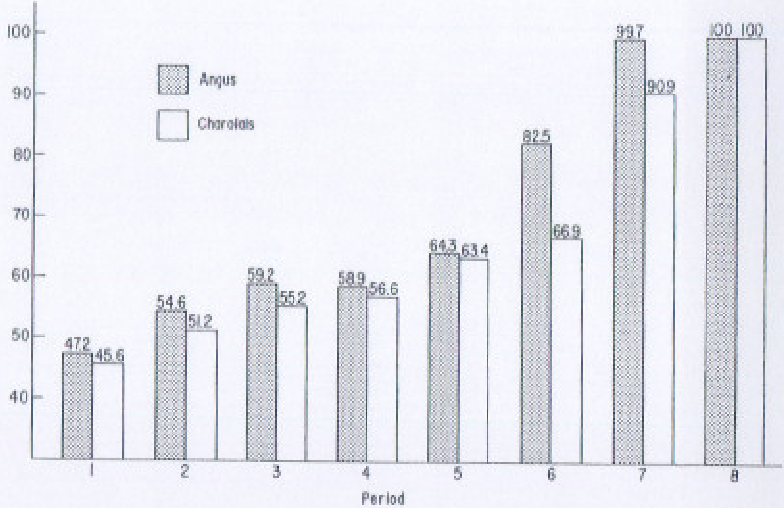

Figure 2. Fiber diameter - percent of final period.

large scale Charolais at all test periods, though this difference was only 0.7 microns at period 8 (Fig. 1). These results strongly suggest that small scale cattle mature earlier and at a faster rate in fiber diameter than large scale cattle. Also it may be noted that most of the increase in fiber diameter (both quantity and rate-wise) occurred post-weaning. This was between periods 5 and 7 for the Angus and between periods 6 and 8 for the Charolais. In general the Charolais followed the same trends in fiber diameter increase as did the Angus, but were 56 days or nearly two months slower.

On a percent net increase basis, the results showed that between periods 1 and 4 there was an approximate 11 percent increase in fiber diameter, while during periods 4 through 8 fiber diameter increased by 42 percent (Fig. 2). This rapid surge in fiber diameter occurred subsequent to the time when bone growth had attained a major portion of its potential development and possibly when the muscle fibers had completed a major portion of their metabolic adaptation. Finally it is pointed out that by 30 days of age the Angus and Charolais calves had already reached 47.2 percent and 45.6 percent of their respective period 8 fiber diameter.

Antibiotic Infusion for Prevention of New Mastitis Infections in Cows

L. J. Bush, P. B. Barto, G. D. Adams and M. E. Wells

Story in Brief

Bovine mastitis is responsible for greater economic loss than any other single disease affecting dairy cattle. Reduced milk yield, altered milk composition, veterinary fees, cost of drugs, and increased herd replacement costs all contribute to the loss encountered.

One of the more promising approaches to reducing the incidence of mastitis in dairy herds is that of preventing new infections during the non-lactating period of the production cycle. This study was conducted to evaluate the effectiveness of infusing a synthetic penicillin, benzathine cloxacillin, into all quarters of cows at drying-off in preventing new mastitis infections.

Infusion of each quarter of the udder at drying-off with 500 mg. benzathine cloxacillin significantly reduced the rate of new mastitis infection in cows up to 4 to 10 days after calving. Rate of new infection was 18.8 percent in control cows compared to 4.6 percent in infused cows. Seventy-five percent of the new infections in cows and 66.7 percent in quarters were detected only by bacteriological examination. No increase in the less common species of mastitis-causing bacteria occurred as a result of dry cow infusion.

Infusion of all quarters of all cows in a dairy herd after the last milking of each lactation with an effective antibiotic preparation can reduce infection rate in a dairy herd. Use of acceptable technique in infusing an antibiotic preparation into the udder of cows is an extremely important factor in obtaining the benefit possible with this management practice.

Introduction

Efforts in the past to prevent or eliminate mastitis infections during lactation were only partially successful for a number of reasons. Most mastitis causing batceria (*Staphylococcus aureus, Streptococcus uberis, Strep. dysgalactiae, Pseudomonas aeruginosa, Escherichia coli, Klebsiella species* and *Corynebacterium pyogenes)* are widely distributed in the environment, so that complete eradication appears to be impossible. *Strep. agalactiae* is limited to the mammary gland, yet many opportunities exist for transfer from cow to cow. In effect, the udder of a dairy cow is constantly exposed to bacteria potentially capable of causing mastitis. The practice which appears to be of greatest value at present in preventing new infections during lactation is that of immersing the teats with an effective bactericidal solution ("teat dipping") after each milking.

More recently, attention has focused on elimination of existing infections or prevention of new infections during the non-lactating period. It is estimated that 50 to 80 percent of all new mastitis infections begin during the dry period; therefore, prevention of new infections during this period would substantially reduce the mastitis problem.

The purpose of this study was to evaluate the effectiveness of antibiotic infusion into all quarters of cows at drying-off in preventing new infections under the environmental and management conditions prevailing in the Southwest. A more detailed report of the results was published in the *Bovine Practitioner*, Nov. 1974.

Materials and Methods

Prior to drying-off, quarter milk samples from all cows in the O.S.U. dairy herd were examined for presence of mastitis causing bacteria. Cows found to be negative (59 Ayrshires, 13 Guernseys, 23 Jerseys, and 77 Holsteins) were grouped on the basis of number of lactations completed and assigned to treatment groups. The treatments were: (a) control, no infusion and (b) infusion of 500 mg. benzathine cloxacillin[1] into each quarter of the udder after the last milking of the lactation period.

All cows in both groups were teat dipped with an iodine solution having 10,000 ppm available iodine once a day for seven days after drying off. Afterwards, the cows were maintained in a pasture separate from the milking herd and periodic examinations of udders by visual observation and palpation were made for any indication of infection during the dry period.

Routine management procedures for the milking herd included proper maintenance of milking equipment, use of strip cup for detection of clinical mastitis, drying each udder with single service paper towels, acceptable milking technique, and teat dipping with an iodine solution after each milking.

[1] Bristol Laboratories, Division of Bristol-Meyers Co., Syracuse, New York.

Infection status was determined by bacteriological examination of quarter milk samples at drying off, 4 to 10 days after calving, and whenever clinical mastitis was detected. Procedures for identifying specific groups or species of mastitis causing organisms, and the criteria for classifying a quarter infected, were those outlined by the Research Committee of the National Mastitis Council.

Results and Discussion

Infusion of benzathine cloxacillin into the udder of cows at drying-off significantly reduced the number of cows developing new mastitis infections during the dry period and the initial 4 to 10 days of the next lactation (Table 1). The number of previous lactations did not significantly influence the effectiveness of antibiotic infusion in preventing new infections. Thus, in a program of dry cow infusion for preventing mastitis, infusion of all quarters of all cows, without regard to age, appears to be indicated.

Only 2 of 25 new infections in quarters were detected by clinical observation during the dry period. Presumably, at least part of the other 23 infections first detected 4 to 10 days after calving also occurred before calving. The first few days after calving has been reported to be one period when cows are particularly vulnerable to new infections. However, since benzathine cloxacillin would be expected to persist in the udder for only four weeks of the dry period, it would be difficult to account for its effectiveness in preventing new infections in this trial had they occurred after calving.

A surprisingly small number of experiments have been reported in which new infection rate in cows infused with antibiotic at drying-off was compared to a control group without infusion. Moreover, a large amount

Table 1. Number of New Infections Developing During the Dry Period

Item	Cows		Quarters	
	Control	Infused	Control	Infused
Number of experimental units	85	87	339[1]	347[1]
Clinical infections detected during dry period	1	0	2	0
Additional infections detected up to 4 to 10 days post-calving	15	4	20	5
Total new infections	16	4	22	5
Percent new infections[2]	18.8	4.6	6.5	1.4

[1] One blind quarter.
[2] Difference between groups statistically significant for cows ($P<.01$) and quarters ($P<.001$).

of variation in the effectiveness of antibiotic infusion may be noted in a summary of these experiments. Some workers have reported reductions in new infection rate similar to that found in this study, whereas less favorable results have been obtained by others. The particular antibiotic used and time of infusion in relation to drying-off are factors which appear to influence the results obtained. In experiments where antibiotic infusion plus teat dipping after the last milking was compared to controls having neither of these, reductions in rate of new infection from 45 to 82 percent have been reported.

Considering all the experiments in which antibiotic infusion at drying-off has been evaluated, there was no definite relationship between level of infection in the herds, as measured by rate of infection in the control group, and effectiveness of antibiotic infusion in reducing new infection rate. Thus, the practice of infusing cows at drying-off can be beneficial even under conditions where a relatively low new infection rate is expected. Whether or not all cows in a herd should be infused depends upon the feasibility of sampling every cow near drying-off to determine infection status, number of new infections expected during the dry period, cost of the drug, and likelihood that the antibiotic infusion would be done in an acceptable manner.

The majority of the new infections up to 4 to 10 days post-calving were determined by bacteriological examination of quarter milk samples (Table 2). Ninety percent of the new infections in cows were determined in this manner, whereas only one-fourth were clinical cases of mastitis. On a quarter basis, 77.8 percent of the infections were detected by bacteriological examination, and only 33.3 percent by observation of clinical mastitis. Thus, it appears that quarter milk samples from all freshened cows would need to be examined bacteriologically to detect a large major-

Table 2. Infections Determined by Bacteriological or Clinical Means up to 4 to 10 Days Post-calving

Method of Detection	No. of Cows or Quarters	Percent Detected By Method Designated
Cows		
Bacteriological	15	75
Bacteriological and clinical	3	15
Clinical only	2	10
Quarters		
Bacteriological only	18	67
Bacteriological and clinical	3	11
Clinical only	6	22

ity of new infections. Otherwise, the majority of new infections would advance to a greater degree of severity, possibly causing severe damage to the secretory tissue before detection during the ensuing lactation.

In the infused cows which did develop infections during the dry period or during the first month of lactation, the same species of common mastitis producing organisms were isolated as were present in the herd prior to initiation of this experiment. There was no evidence of an increase in the occurrence of the less common species of bacteria which occasionally cause mastitis.

Considering only cows free of mastitis at 4-10 days after calving, infusion before the dry period did not appear to influence susceptibility to infection during the first month of lactation. During this period, there was a similar percentage of new infections in cows which had been infused during the previous dry period and control cows (10.8 vs. 8.7 percent, respectively). New infection rate in the treated and control quarters was 3.6 and 2.2 percent, respectively. No evidence was obtained in the present study to support the idea that untreated quarters which possess non-pathogenic bacteria at drying-off may have a lower rate of new infection than treated quarters in the ensuing lactation.

Studies on Wheat Pasture Flavor in Milk

R. L. Von Gunten, L. J. Bush, M. E. Wells, G. V. Odell, and G. D. Adams

Story in Brief

Unmanaged handling of dairy cows grazing wheat pasture will permit milk to be produced containing an undesirable flavor and odor. Feeding sorghum silage at the rate of two percent of body weight just prior to grazing the wheat pasture for two hours had the effect of slightly reducing the intensity of the wheat flavor in the milk. This method of handling the feeding program was compared to feeding the silage after the wheat-grazing period and after the evening milking. The wheat flavor was not completely eliminated by feeding silage at either time. Feeding

silage prior to grazing may have only influenced the total amount of wheat forage consumed.

More study on measuring the amount of wheat forage consumed is being implemented in an attempt to relate the off-flavor in milk with blood and rumen constituents. Continued laboratory work is being directed toward a practical field testing system for the evaluation of the amount of wheat-produced off-flavor.

Introduction

Wheat pasture forage is an important dairy cattle feed crop in Oklahoma and the Southwest. This crop cannot be completely pastured though, as it will cause the milk produced by cows using this forage to have a "fishy" odor and taste. This off-flavor, caused by trimethylamine in the milk, is severe enough to cause rejection of milk by dairy processing plants.

While it is true that there are other off-flavor problems possible at the farm, it has been reported by the Producers Association in Oklahoma that approximately 25 percent of the rejected milk was "wheat flavored" this past November, December, and January. The occurrence of wheat flavored milk was less during the early winter grazing season of 1974 than last year, possibly because of improved herd management by the producers or different climatic conditions for wheat during this growing season. The most severe period for wheat flavored milk is expected during February and early March.

In previous work at the Oklahoma station, the length of time that cows grazed wheat pasture influenced the intensity of wheat flavor in their milk. In trials early in 1974, feeding of grain prior to grazing wheat forage had no effect upon flavor intensity when compared to not feeding the grain prior to grazing.

The purpose of this work was to determine whether feeding silage to cows at different times relative to wheat pasture grazing would influence the intensity of wheat flavor in the milk.

Materials and Methods

Twelve Holstein cows that had freshened in July or August of 1974 were divided into three groups at random. All groups were fed silage at the rate of 2 percent of body weight. Grain was fed at the rate of 1.5 percent of body weight, and alfalfa hay at the rate of 0.5 percent of body weight. All groups were fed one half their grain ration at 4:00 a.m. and all their hay at 8:00 a.m.

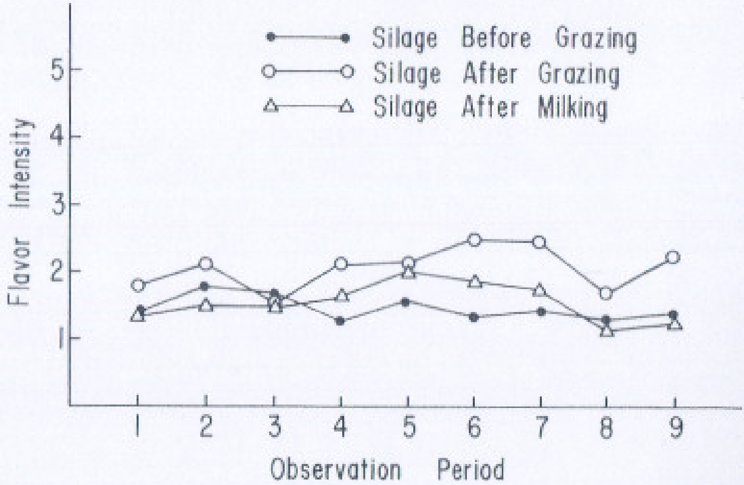

Figure 1. Average wheat flavor intensity in milk from cows grazed on wheat pasture, 1974-75 trials.

The variable treatments were as follows: Group number I was fed its total silage and the balance of its grain ration just before grazing. Group number II was fed its silage and the balance of its grain after grazing, and group number III was fed its silage and the balance of its grain immediately after the evening milking. All cows were put on good quality wheat pasture at 1:00 p.m. and allowed to graze for two hours. After a two hour delay, all cows were milked and samples of milk taken. Approximately 20 hours later, these cooled samples were divided into two equal portions and randomized for tasting by three trained milk flavor judges. Their scoring system was: 1 = no detectable wheat flavor, 2 = slight flavor, 3 = distinct flavor, 4 = strong flavor, 5 = very strong flavor. Sampling periods were approximately one week apart.

Results and Discussion

Average intensity of the wheat flavor in the milk was only moderate during most of this trial period (October 31, 1974-January 9, 1975). This was in contrast to a similar period a year ago at this station. It would appear that less wheat flavor developed in milk from the cows fed silage after milking, than in milk from cows fed silage after grazing the wheat forage. Cows fed silage just prior to grazing produced milk with less wheat flavor than those fed silage after grazing, but their flavor scores were more erratic. There may be a connection between cow capacity and urge to graze at the time of feeding, rather than the kind of feed, that influenced the amount of wheat flavor in the milk. In further tests involving different silage feeding times the amount of wheat forage consumed is being determined, to resolve this question.

As yet, there is not a satisfactory "field testing kit" devised that can be truck transported and driver operated to assist the driver in making the decision on whether a tank of suspected wheat flavor milk is acceptable or not. This is very difficult to do because the taste "threshold" for the compound responsible for the flavor, trimethylamine, is quite low, i.e. 3 ppm. Nevertheless, our laboratories are continuing their efforts to devise a practical small testing system.

Comparison of Finely Ground and Micronized Sorghum Grain for Dairy Cows

L. J. Bush and G. D. Adams

Story in Brief

Since grain comprises a large part of the feed cost for dairy cows, it is important to determine whether processing by different methods will improve its feeding value. In this trial, sorghum grain processed by fine grinding was compared to grain micronized to different degrees.

Yield and composition of milk was similar for cows fed grain processed by fine grinding or micronizing. In particular, micronized grain had no consistent effect on milk fat test as one or more cows in each treatment group had lower fat tests than usually expected.

Introduction

In previous feeding trials, micronized sorghum grain was found to be essentially equal to finely ground or steam rolled grain in terms of milk yield by dairy cows. However, there was some evidence of depressed fat tests when micronized grain was fed. For this reason, the trial reported last year and the current one were designed as continuous type trials wherein cows were fed the same ration throughout the trial. While this type of trial is not as sensitive as other types in terms of detecting differences in milk yield that may result from different processing methods, it was deemed appropriate because any ration effects on fat test were considered to be long term in nature.

The purpose of this trial was to compare sorghum grain micronized to different degrees with finely ground grain in terms of yield and composition of milk of dairy cows.

Materials and Methods

Twenty-four lactating cows (12 Ayrshires and 12 Holsteins) were used in a continuous type trial to compare rations containing sorghum processed by (a) fine grinding (1/16 inch screen), (b) micronizing (30 lb. test wt.) or (c) micronizing (18 lb. test wt.).

Sorghum grain comprised 75 percent of the concentrate mixture (Table 1) which was fed in a 50:50 ratio with excellent quality alfalfa hay. The cows were challenge fed during a 2 to 3-week adjustment period starting about 2 months after calving, with only the restriction that approximately equal amounts of grain concentrate and hay be consumed. Ration allowances for the comparison period of the experiment were calculated to meet 1971 NRC requirements with due consideration for body size, age, milk yield and fat test. Each cow was fed the calculated amount of feed for a 2-week preliminary period and then the same amount of experimental ration each day throughout an 8-week trial.

Milk production was recorded twice daily, with samples from four consecutive milkings each week composited for analysis of total solids and fat percentage. Body weights were recorded on three consecutive days at the start and end of the trial.

Table 1. Ingredient Composition of Ration.

Ingredient	Percent
Sorghum grain[1]	75.0
Soybean meal	10.0
Molasses, liquid	7.5
Corn, ground	5.0
Urea	1.0
Dicalcium phosphate	1.0
Trace mineral salt	0.5

[1] Processed as required for different experimental rations.

Results and Discussion

Method of processing sorghum grain fed cows in this trial did not have a consistent effect on total yield or composition of milk. The higher average daily yield by the cows fed grain micronized to a minimum degree (30 lb. test wt.) was judged to be a reflection of differences among cows in persistency of production as there was considerable variation among cows within each group (Table 2).

There was a downward trend in milk fat test of around .2 to .3 percent in all the groups during the 8-week trial. Conversely, the percent non-fat solids in milk increased gradually during the trial. Presumably, these changes in milk composition were merely a reflection of the stage of lactation. In any event, there was sufficient variation among cows within each ration group that differences among groups in average fat tests were not considered to be of real importance. One or more cows in each ration group had lower fat tests throughout the trial than is usually expected.

On the basis of the results obtained to date, it may be concluded that micronizing is equal but not superior to fine grinding as a method of processing grain for dairy cow rations. On the other hand, micronized grain would be expected to have greater feeding value for lactating cows than coarsely ground or dry-rolled sorghum grain.

Table 2. Average Feed Intake and Milk Yield.

	Method of processing grain		
Item	Finely ground	Micronized 30 lb./bu.	Micronized 18 lb./bu.
Feed intake[1]			
Concentrate, lb./day	18.0	18.9	20.2
Hay, lb./day	18.0	18.0	19.2
Milk production			
Yield, lb./day[2]	48.2	49.1	48.1
Fat test %[2]	3.7	3.4	3.5
Non-fat solids, %	9.10	9.02	9.14
Weight change, lb./8 wk.	16	6	—9

[1] Dry matter basis.
[2] Averages adjusted by covariance analysis on basis of initial yield and fat test, respectively.

Starters for Cheese Whey Fermentation

Leslie Redel, Wanda Smith, and J. B. Mickle

Story in Brief

Three different methods of starter storage were investigated on a laboratory scale for the growth of *K. fragilis* yeast starters in cottage cheese whey. Starters were frozen, stored at refrigerator temperatures, and propagated using a "progressive transfer technique" which involved saving a small portion of the fermented whey each time yeasts were grown, to use as a starter in the next batch. This progressive transfer appeared to have the most possibilities for use on the laboratory scale. Frozen starter can be used up to about four weeks, after which it loses some of its vitality. The refrigerated starter was the poorest technique of the three, and could only be used to store starters for two weeks.

Introduction

The food processor has problems when disposing of his wastes. It must be disposed of in such a manner that the Environmental Protection Agency's standards, as well as those of the local government are met. Food wastes are quite concentrated as compared to the sewage normally in the city sewers. Thus, a large food plant can dump enough waste solids into the sewer system to overload the city's treatment facilities. Many cities in Oklahoma and elsewhere, will not allow such large amounts of waste in their sewers. Even if they do, an extra sewer tax for each increment of solids is often added to the plant's cost. The standards set by the Environmental Protection Agency last January, are fairly severe. For example, the dairy industry can only put 0.1% of the solids in the sewer which originally entered the plant. This makes a tremendous problem of controlling what goes down the sewer. Although the regulations have not all been written yet, we're told that similar standards may face the meat industry and other food processors in the near future.

Pretreating food wastes to remove the Biological Oxygen Demand (BOD) before dumping the waste in the sewer can cost a great deal of money. For example, one filtering apparatus used by some large dairy plants costs over $500,000. The filtered material from the unit goes down the drain and often, nothing is recovered—and the money spent on it is a "dead loss."

It would be of great benefit to the food processor, as well as the consuming public, if usable nutrients could be recovered from these food wastes before they are put in the drain. In the past this has not been considered economically practical, since food wastes are quite dilute and other sources of food and feed were plentiful. Now, however, the situation is different. The price of animal feed has risen tremendously, as has the price of human food. Whole new industries have grown up around the idea of finding substitute proteins or fats for human foods. It appears that we will shortly have to look for substitute sources of protein and fat in animal feeds if current methods of handling domestic animals are to continue. One such source might be from food wastes, since these contain "high quality" proteins. In addition to being cheaper than existing sources of animal protein, the recovery of these nutrients could be a great help to the food processor in offsetting the cost of pretreating his waste materials.

Previous work at OSU has shown that fermentation techniques can solve the waste disposal problem for cottage cheese whey. On the laboratory scale, fermentation removes 99+ percent of the BOD after 24 hours fermentation. The same principle applied to cheese whey could easily be applied to other food wastes, i.e., those from slaughter houses, packing plants, milk bottling operations, etc. The procedure already is in commercial use with cheese whey at one location in California. Another multimillion dollar operation is being built to handle petroleum wastes in the United States. This procedure also is used to handle wastes from large petroleum and paper industries in England and France. The particular contribution of OSU work is that it can be applied to food plants of any size, large or small, whereas other techniques are applicable only to multimillion dollar installations. The OSU process is now ready to be "scaled up" to pilot plant size to determine what difficulties exist on a larger scale that were not anticipated in the laboratory. One of the first problems was that some new method of handling the initial yeast inocula (starter) would be desirable. In the laboratory a 30 percent starter inoculation (by volume) had been used. When fermenting 1,000 gallons of whey in the pilot plant, however, this required a starter volume of 300 gallons—a sizeable operation in itself. Thus, the first problem, which was solved last fall, was to develop a method of concentrating starters.

Methods and Results

After studying several possibilities, the procedure best adapted for our use was to obtain an initial batch of yeast starter, then concentrate the yeast organisms by gravity, filtration or centrifugal force. They then were stored in this concentrated form until used. It was found that in order to store *K. fragilis* yeast (the one used in this work) for any period of time, it was necessary to have a media which contained its growth requirements. However, the volume of that media could be greatly reduced. For example, starting with 300 pounds of starter, only four pounds of cells were obtained, after settling by gravity, or filtration. After trying

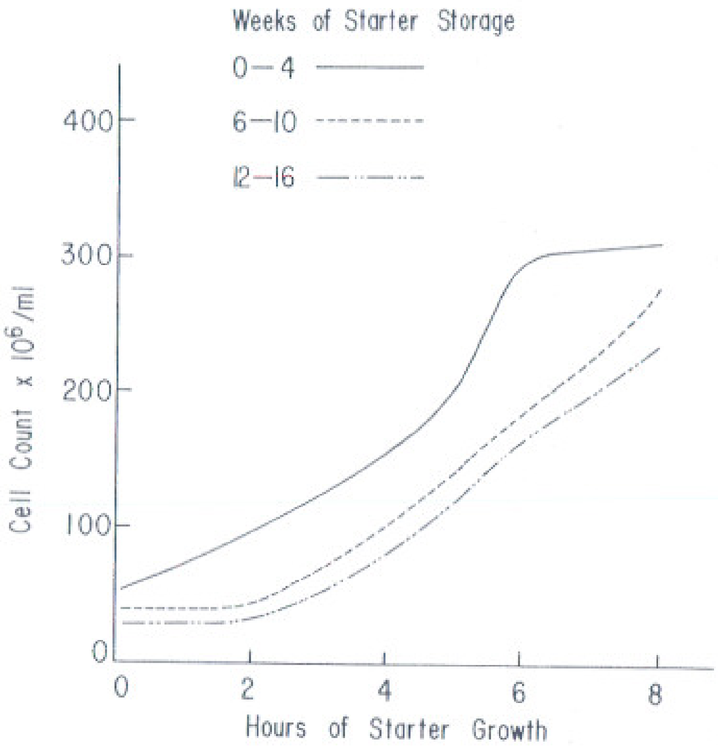

Figure 1. Growth of K. fragilis **starter in cottage cheese whey at 35°C[1] after various periods of frozen storage[2]**

[1]K. fragilis plated on yeast-malt extract agar after storage.
[2]Frozen storage at 0°F starter removed, grown in whey and counted every two weeks for 16 weeks. Each batch innoculated at the rate of 0.8% starter to whey.

several growth substances it was found that sucrose (table sugar) was as good a growth media for the yeasts as any other which was readily available. Thus, after obtaining the initial four pounds of yeast, they were stored in an equal volume of water containing 50 percent sucrose.

Three different types of storage were used. First, the cells were frozen (0°F). At each two week period a portion of the frozen cells were removed from storage and added to cheese whey. The growth curves showing the performance of these yeasts were then plotted by counting the numbers of yeasts using a yeast-malt agar obtained from the Northern Regional Research Laboratories in Peoria, Illinois. The results of this trial (Fig. 1) showed the starter organisms retained their original vigor for about four weeks, after which there was a considerable drop in their vitality which slowed the growth rate of the organisms in cheese whey. Even so, the frozen starter could be used for periods of up to 16 weeks of storage with no more than a 2-3 hour loss in time of reaching maximum growth during cheese whey fermentation.

The second technique was to take a similar sample of the *K. fragilis* yeasts and store them at refrigerator temperatures (38°F). In this case (Fig. 2) the yeasts lost a portion of their vitality within two weeks, but this reduced growing ability was maintained for eight weeks thereafter. After ten weeks, however, so many of the starter cells had died that they would have been of little practical value in the commercial fermentation of whey, since it took 4-6 hours for the yeasts to begin growing.

The third technique used in the laboratory was to obtain yeast organisms, as before, store them in the refrigerator at 38°F. for two weeks, then use them in fermenting a batch of whey. From this first fermentation then, a small portion was removed after five hours growth, when the cells were in their most rapid growing stage. These cells were rediluted in 50 percent sucrose solution, stored another two weeks, then used again to ferment another batch of whey. From this second batch of whey, a second portion of yeast was obtained after 5 hours growth, the cells concentrated, stored, and used again.

This technique (called progressive transfer) was continued for a period of 14 weeks with whey fermentation at two week intervals. Only two weeks of storage was involved and no loss of yeast vitality was noted in the starter (Fig. 3). At the end of 14 weeks the starters were growing just as fast as they had at the beginning. Thus, for rapid growth of starters this progressive transfer seemed to be the most applicable.

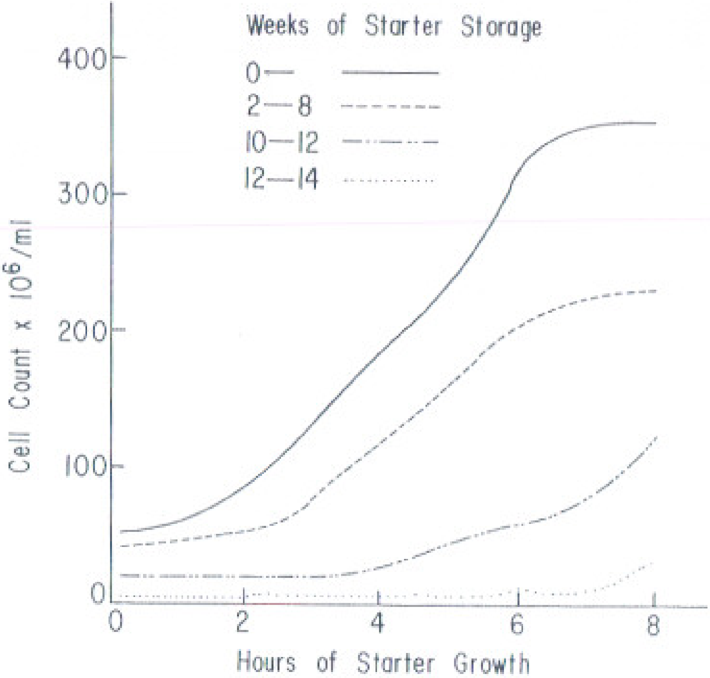

Figure 2. Growth of K. fragilis **starter in cottage cheese whey at 35°C[1] after various periods of refrigerated storage[2]**

[1]K. fragilis plate counts on yeast-malt extract agar.
[2]Storage at 38°F, removed, grown in whey and counted every two weeks for 14 weeks. Each batch innoculated at the rate of 0.8% starter to whey.

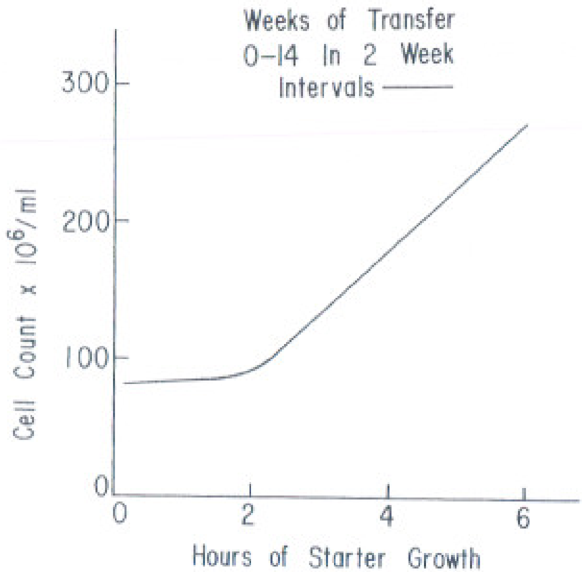

Figure 3. Growth of K. fragilis **in cottage cheese whey at 35°C after progressive transfers[1]**

[1]**K. fragilis** plate counts on yeast-malt extract agar. Starter organisms recovered after 4-5 hours from each whey growth. Stored at 38°F for two weeks then used to innoculate the next batch of whey.

A New Custard for the Elderly

J. B. Mickle, Olive Pryor and R. D. Morrison

Story in Brief

A new baked custard with fewer calories, higher protein, and a lower fat content was developed and tasted by a group of senior citizens. This custard was dried—when ready to serve, water was added and the custard was baked in the usual manner. The taste panel of senior citizens liked this dried custard just as well as the fresh product. They also preferred the custard which was approximately twice as sweet as normal, but preferred the normal texture as opposed to a thicker one which was more like a pudding.

Introduction

Because of decreasing birthrates and increasing life spans, the average age of the American population is continually shifting upwards. Thus, a larger and larger percentage of our population are being classed as elderly (over 55). A great deal has been written about the problems of the elderly. They often are malnourished, particularly in terms of protein, minerals, and certain vitamins.

While the research reported here deals with nutritional deficiencies of the elderly and the fabrication of foods for them, one must also be aware of the senior citizens' other problems since these limit their food sources. For example, many of them wear false teeth and thus they can't chew certain foods. Many of them are ill, and are on restricted diets. The literature concerning most of these problems has been reviewed (2). The purpose of this research was to develop new foods which the elderly could eat, but which were higher in proteins and some of the other nutrients normally lacking in their diet.

Experimental

As a first step, a group of senior citizens were located who were willing to give information about their food preferences. A survey of this group's eating habits was conducted and the results reported last year (2). The survey pointed out that one of the foods which senior citizens would prefer, was a baked custard similar to that of their youth. However, no such product was available on today's market. Accordingly, recipes were developed which had the appearance and taste of baked custards, but were higher in protein and other food nutrients than the puddings which are currently available (2).

Results

After preliminary work it was found that the main items affecting the food preference of the senior citizens, were the sweetness and texture of custards. Accordingly, a basic recipe was chosen (Table 1), then the sweetness increased by substituting fructose (from honey) for table sugar, increased thickness was obtained by adding gelatin. To assemble the custards, liquid ingredients were first heated to scalding (150°F), the solid ingredients were then mixed together and added to the liquid with stirring. Finally, the eggs were added and the entire custard then mixed into a homogeneous liquid, using a laboratory hand homogenizer or a Waring blender. Aliquots of each mix were then poured into 50 ml beakers, which were baked at 350°F (Figure 1).

Table 1. Composition of OSU custards.

	A (N-N) Normal Sweetness Normal Texture	B (H-N) High Sweetness Normal Texture	C (N-T) Normal Sweetness Thick Texture	D (H-T) High Sweetness Thick Texture
Milk	43.0	43.0	43.0	43.0
Skim	24.4	24.4	24.4	24.4
Eggwhite	23.0	23.0	23.0	23.0
Sucrose	6.0	5.0	6.0	5.0
Fructose	0.0	4.0	0.0	4.0
Gelatin	0	0	0.6	0.6
Emulsifier[1]	0.01	0.01	0.01	0.01
Water	3.6	0.6	3.6	0.6

[1] Tween 81, Atlas Chemical Co. Polyoxyethlene (5) sorbitan monostearate HLB 10.0.

Figure 1. Baking high protein custards at OSU for the taste panel of senior citizens.

At each tasting period the senior citizens on the taste panel received two plates, each containing two beakers of custard. From each plate the judges were asked to choose the custard they preferred. To complete a trial, six comparisons were necessary (AB, AC, AD, BC, BD, and CD—see Table 1). Thus, with each judge receiving only four samples at a time, three tasting sessions (or 12 comparisons) were necessary to complete the trial in duplicate. To neutralize any differences due to different days, each judge made each of 12 comparisons in a completely random order. In addition, samples were randomized as to their position on the plate (left or right). This randomization, together with the data analysis, was programmed on the computer with the SAS procedure (1). This program called upon a modified Chi-square procedure for data analysis.

Results

When the two variables, sweetness and texture, were compared, the senior citizens on this panel preferred the sweeter product. This custard was almost twice as sweet as that of a normal product. The senior citizens also preferred a normal texture similar to that they had known in their youth, i.e., one which "leaked" water after the first spoonful was taken. The thicker custard had a texture more like the puddings on today's market. When the variables were confounded (i.e., the preferred sweetness combined with the thicker custard) the judges were unable to make a distinct choice (Table 2). The 12 comparisons were repeated three times in duplicate. The first time the custards were made entirely with fresh ingredients, the second time milk powder was substituted for the fresh skim milk, and the third time dried egg whites were substituted for the fresh egg white. Unfortunately, some of these dry ingredients had an aftertaste due to their previous processing, which confused the judges.

Table 2. Preferences for baked custards by senior citizens.

Mix and Description				
(Mix)	(Sweetness)	(Thickness)	Mean[1]	Rank
A	normal	normal	1.52	2
B	high	normal	1.15[2]	1 (best)
C	normal	high	1.78[3]	4 (worst)
D	high	high	1.55	3

[1] Custards were scored by pairs as "1" for the best and "2" for the worst, thus the lower the mean, the better the custard. Means were computed over six possible comparisons: A vs B, A vs C, A vs D, B vs C, B vs D, and C vs D.
[2] Mix A (high sweetness and normal texture) was statistically different from the other three (probability = 0.001% with 108 degrees of freedom).
[3] Mix C was statistically different from mixes A and D at the 0.025% level of probability with 84 degrees of freedom.

This made the data analysis of questionable value.

Therefore, a third trial was conducted, using a single custard (No. B), for which the taste panel had indicated a preference. A large batch of this custard mix was assembled, then divided into two parts. The first part was stored in the refrigerator until baked. The second part was freeze-dried, a procedure which removes moisture at subzero temperatures, and is used to dehydrate many foods today. The dried mix was then reconstituted with water to its original volume, and the two custards were baked in the usual manner. These two custards then were presented to the panel after the usual randomization and duplication. Statistical analysis of the results showed that the senior citizens could tell no difference between those custards made from the fresh or dry ingredients (Table 3).

Table 3. Taste panel preferences for custards made with fresh or dry ingredients.[1]

Preferences		Chi Square	Significance
17	23	1.80	$P > 0.10$

[1] Custard B: High sweetness, normal texture. One batch mixed then divided, the first (fresh) was stored for a week, then baked, while the second (dry) was freeze-dried, reconstituted, then baked.

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Synchronization of Estrus in Beef Cattle With Prostaglandin

E. J. Turman, R. P. Wettemann, T. D. Rich, D. Lyons, W. E. Sharp, and R. R. Frahm

Story in Brief

A single intramuscular injection of 30 mg of the prostaglandin, $PGF_{2\alpha}$–Tham salt, was administerd to 27 crossbred beef heifers and 19 lactating beef cows whose levels of blood progesterone indicated they were cycling and had a functional corpus luteum. Estrus was observed within 8 days in 96.3 percent of the heifers and 78.9 percent of the cows. The average time from treatment to estrus was 2.35 days in the heifers and 3.40 days in the cows.

Fifteen heifers and 7 cows treated with prostaglandin were artificially inseminated 12 hours after the onset of estrus, with 73.3 percent of the heifers and 71.4 percent of the cows conceiving. This was very similar to the conception rates in the untreated controls of 76.7 percent and 69.0 percent for heifers and cows, respectively. One prostaglandin treated group of 11 cows and 12 heifers were inseminated once 80 hours after $PGF_{2\alpha}$ treatment regardless of when, or whether, estrus occurred, with 50.0 percent of the heifers and 36.4 percent of the cows conceiving.

An additional 40 cows and 41 heifers that were not cycling, and did not have a functional corpus luteum were also injected with $PGF_{2\alpha}$. In this group, only 9 cows (22.5 percent) and 6 heifers (14.6 percent) showed signs of estrus within 8 days, and only two of the cows and none of the heifers conceived at this estrus.

The data obtained in this study suggests that if a cow has a functional corpus luteum on her ovary at the time of treatment, prostaglandin will effectively synchronize estrus. It further suggests that normal fertility will be obtained at this synchronized estrus.

Appreciation is extended to Dr. J. W. Lauderdale of The Upjohn Company, Kalamazoo, Michigan for providing the prostaglandin used in this study.

Introduction

Estrus synchronization is a subject that is of particular interest to cattlemen that are practicing, or desire to practice, artificial insemination. This is to be expected, since any method that would reduce the labor requirements and/or increase the efficiency of heat detection would be of great value in a beef AI program.

A large number of research studies have been devoted to this subject over the past quarter of a century. Methods and materials have varied from study to study, but all have had one thing in common, namely attempting to remove all cows from under the influence of the hormone progesterone at about the same time. Since the primary source of progesterone in the female is a structure on the ovary called the corpus luteum (CL), it is obvious that any effort at estrus synchronization must be concerned with altering it's function.

In a normal estrus cycle of 20-21 days duration, the corpus luteum begins to form on the ovary immediately following ovulation. It becomes functional within the next 5 to 7 days, reaching it's maximum functional level by 10 to 12 days, then slowly regressing to become relatively nonfunctional by day-16 or 17. During the time the CL is functional the progesterone it produces inhibits the growth and development of another ovarian structure called a follicle. By day 16 or 17 the levels of progesterone have dropped sufficiently to remove this inhibition, permitting a follicle to begin to grow rapidly on the ovary. The maturing follicle produces the female hormone, estradiol, which within 3 or 4 days reaches a level sufficiently high to cause estrus, or heat. The egg, which also develops within the follicle, reaches maturity, is released in the process of ovulation some 10 to 14 hours after the end of estrus, and the cycle repeats.

Basically, synchronizing the onset of estrus, depends on removing all cows from under the influence of their CL at the same time. Until recently the only available procedure was to treat the cows with progesterone at levels high enough to inhibit follicular maturation, regardless of how much progesterone their own CL's are producing, for a period of time long enough to insure that the CL's in all of the cows will regress. At such time, stopping the exogenous hormone would immediately drop the progesterone level of all cows, permit rapid follicle growth and estrus should follow within 3 to 4 days.

Within a herd of cows one would expect to find cows at all stages of the cycle; from those that had just ovulated whose CL is just forming and should remain functional for the next 16 days, to those that are just ready to come into heat and whose CL is non-functional. The cows that had just ovulated would determine how long the entire group must be treated with progesterone to guarantee that the CL of all cows would be completely regressed. Since their CL's would be expected to be functional for approximately 16 days, it was necessary to provide the exogenous progesterone for 14 to 18 days. In the earliest studies the progesterone was given in daily injections, since it was not effective when taken by mouth. This was not only time consuming, but fertility at the synchronized estrus was very poor.

With the development of compounds with progesterone-like activity, called progestogens, that could be fed, there was a renewal of interest in estrus synchronizing studies. Several such compounds were developed which could be fed daily for 18 days and result in fairly good synchronization. Despite the disadvantages of requiring daily feeding, which could be a problem in cattle running on lush pasture, and a reduced fertility at the synchronized estrus, at least three pharmaceutical companies put progestogens on the market for use in practical livestock production. These compounds have since been withdrawn and are not now available, nor are they likely to again become available.

Within the last three years, research in estrus synchronization has again been stimulated by the discovery that a naturally occurring compound called prostaglandins were very effective in synchronizing estrus in females of a number of species, including cattle, sheep and horses. This is not a new compound since it was first identified many years ago, but it has been only recently that the wide variety of it's physiological effects have been determined. Prostaglandins function in estrus synchronization by causing a very rapid regression of a functional corpus luteum, with most females in estrus within 3 or 4 days after a single intramuscular injection. It has an additional advantage of having little, or no, detrimental effect on fertility. It has the disadvantage that it is effective only when there is a functional CL present to regress. It will not cause an anestrus cow (that is, one that is not cycling) to come to heat. Nor will it cause the regression of a young CL that has not become functional, which means that the cow be at least 7 days into her cycle when she is treated. The most important disadvantage at the present time is probably the fact that the prostaglandins are still experimental, and have not been cleared by the FDA for use in practical cattle production.

The purpose of this experiment was to study the effectiveness of a single intramuscular injection of prostaglandin in synchronizing estrus and ovulation in non-lactating beef heifers and lactating beef cows maintained under range conditions.

Materials and Methods

This study was conducted in April and May, 1974, utilizing 98 lactating mature beef cows and 105 crossbred beef heifers maintained under range conditions at Lake Carl Blackwell range. Both groups were part of the breeding herd of Project 1502, *Comparison of Lifetime Productivity Under Range Conditions Among Certain F_1 Crossbred Cow Groups.*

Three treatments were imposed:

Treatment A – Prostaglandin injected, breeding at time of estrus post-injection–Ovarian activity determined by rectal palpation. Animals with a corpus luteum given an intramuscular injection of 30 mg of $PGF_{2\alpha}$–Tham salt. Cows observed for signs of estrus and inseminated 12 hours after the onset of estrus.

Treatment B – Prostaglandin injected, breeding on schedule – Ovarian activity determined by rectal palpation. Animals with a corpus luteum given an intramuscular injection of 30 mg of $PGF_{2\alpha}$–Tham salt. All animals inseminated 80 hours post-injection regardless of time of occurrence of estrus.

Treatment C – Uninjected controls – Inseminated approximately 12 hours after the onset of a naturally ocurring estrus.

Vasectomized bulls were used to assist in heat detection. Animals were observed twice daily for onset of estrus. The frozen semen used for all inseminations was obtained from a commercial AI organization.

Blood samples were collected at varying times from animals in Treatments A and B. The plasma was frozen until the levels of progesterone could be determined by radioimmunoassay.

Heifers: All heifers were crossbreds, having either an Angus or Hereford dam and a Hereford, Angus, Simmental, Brown Swiss or Jersey sire. A description of the heifer group is presented in Table 1.

Rectal palpations to determine ovarian activity were carried out on April 22 and April 29. On each palpation day heifers that had not been previously assigned to a treatment group were palpated until 34 were found with an active corpus luteum. These were immediately injected with 30 mg $PGF_{2\alpha}$ and randomly assigned to either Treatment A or B. An attempt was made to balance the heifers between the two treatment groups according to the breeding of their sire. In an effort to keep the average date of insemination of the heifers of the three groups as nearly

Table 1. Description of Heifer Group Classified on the Basis of Breeding of Their Sire.

Item	Breeding of Sire				
	Hereford	Angus	Simmental	Brown Swiss	Jersey
Total number of heifers	13	11	25	24	32
Avg. Wt. on 4-8-74 (lb.)	499	471	554	502	477
Avg. Age on 4-22-74 (days)	416	433	420	420	421
Number of heifers assigned to:					
Treatment A	3	4	10	11	6
Treatment B	2	4	10	10	8
Treatment C	9	3	5	3	18

alike as possible, the insemination of control heifers was started on April 14, one week before the day of first $PGF_{2\alpha}$ injection. All heifers observed in estrus prior to April 22 were inseminated and assigned to the Treatment C, as were all heifers in estrus between April 22 and April 29 that had not yet been assigned to a treatment group.

Blood samples were obtained from heifers of Treatment groups A and B on days 3 and 11 following $PGF_{2\alpha}$ treatment. The heifers were artificially inseminated at the first estrus following the start of the study using frozen semen from a Red Poll or Shorthorn bull. All subsequent breedings were by natural service to pickup bulls of these two breeds.

Cows: This group included 49 Hereford and 49 Angus cows. Most had calved in February and March. All of the Angus cows and 41 Hereford cows were suckling a calf at the time the treatments were imposed.

As was the case with the heifers, an attempt was made to keep the average date of insemination as nearly alike as possible for all treatment groups by starting the inseminations of control cows one week before the start of $PGF_{2\alpha}$ treatment. Beginning on April 29, any cow observed to be in estrus was inseminated and assigned to Treatment C. On May 6, all cows that had not been assigned to Treatment C were palpated. A total of 59 cows were determined to have active corpora lutea, were injected with 30 mg $PGF_{2\alpha}$, and 31 assigned to Treatment A and 28 to Treatment B. The remainder of the cows were assigned to Treatment C, to make a total of 39 cows in this group.

Three blood samples were collected from all cows of Treatments A and B: at time of treatment, on day 3 and on day 11 post-treatment. The cows were artificially inseminated either on day of estrus (Treatments A and C) or 80 hours post-treatment (Treatment B) using frozen semen from Simmental bulls.

Results and Discussion

The results are presented in Tables 2 and 3 for heifers and cows, respectively. When based on the total cows and heifers treated, it is apparent that the response to prostaglandin was very disappointing. Data that have been reported from other experiment stations have suggested that 75 percent or more of the treated animals could be expected to be in heat within 8 days of treatment with prostaglandin. In the present study, however, only 41 percent showed estrus at the expected time following treatment.

The progesterone data provides a very logical explanation for the poor overall performance of the cows and heifers in this study. Originally it was planned to bleed the animals only on day 3 and day 11 following treatment. This was based on the expectation that palpation would reveal those animals that had a corpus luteum and were producing progesterone. The day 3 blood sample should contain very little progesterone, evidence that the prostaglandin had caused the corpus luteum to regress. The day 11 sample should be relatively high in progesterone, indicating the cow had been in estrus soon after prostaglandin injection, ovulated and formed a new corpus luteum that was now functional. Thus, based on pro-

Table 2. The Occurrence of Estrus and Conception Rates of Crossbred Beef Heifers Treated With Prostaglandin.

Item	Treatment Group		
	A	B	C
TOTAL HEIFERS:			
Number	34	34	37
No. in estrus in 1st 20 days	16	16	37
No. in estrus within 8 days post-$PGF_{2\alpha}$	16	16	--
Avg. days to estrus post-$PGF_{2\alpha}$	2.31	2.81	--
Range in days to estrus post-$PGF_{2\alpha}$	1 - 4	1 - 5	--
No. conceived at 1st insemination post-trt.	11	6	28
Percent conceived at 1st insemination post-trt.			
of total heifers in study (%)	32.4	17.6	76.7
of heifers in estrus (%)	68.8	37.5	76.7
HEIFERS WITH TYPICAL BLOOD PROGESTERONE LEVELS:[1]			
Number	15	12	--[2]
No. in estrus within 8 days post-$PGF_{2\alpha}$	15	11	--
Avg. days to estrus post-$PGF_{2\alpha}$	2.27	2.45	--
Range in days to estrus post-$PGF_{2\alpha}$	1 - 4	1 - 5	--
Percent in estrus within 8 days post-$PG_{2\alpha}$ (%)	100.0	92.5	--
No. conceived at 1st insemination post-trt.	11	6	--
Percent conceived at 1st insemination post-trt. (%)	73.3	50.0	--

[1] Typical blood progesterone levels defined as less than 1 ng/ml plasma at 3 days post-$PGF_{2\alpha}$ and greater than 2 ng/ml plasma at 11 days post-$PGF_{2\alpha}$.

[2] Progesterone levels not determined for heifers of Treatment C.

Table 3. The Occurrence of Estrus and Conception Rates of Lactating Hereford and Angus Cows Treated With Prostaglandin.

Item	Treatment Group A	Treatment Group B	Treatment Group C
TOTAL COWS:			
Number	31	28	39
No. in estrus in 1st 20 days	14	10	29
No. in estrus within 8 days post-$PGF_{2\alpha}$	14	10	---
Avg. days to estrus post-$PGF_{2\alpha}$	3.35	2.70	---
Range in days to estrus post-$PGF_{2\alpha}$	1 - 7	1 - 8	---
No. conceived at 1st insemination post-trt.	7	4	20
Percent conceived at 1st insemination post-trt.			
of total cows in study (%)	22.6	14.3	51.3
of cows in estrus (%)	50.0	40.0	69.0
COWS WITH TYPICAL BLOOD PROGESTERONE LEVELS:[1]			
Number	8	11	---[2]
No. in estrus within 8 days post-$PGF_{2\alpha}$	7	8	---
Avg. days to estrus post-$PGF_{2\alpha}$	3.57	3.00	---
Range in days to estrus post-$PGF_{2\alpha}$	1 - 7	2 - 8	---
Percent in estrus within 8 days post-$PGF_{2\alpha}$ (%)	87.5	72.7	---
No. conceived at 1st insemination post-trt.	5	4	---
Percent conceived at 1st insemination post-trt. (%)	71.4	36.4	---

[1] Typical blood progesterone levels defined as greater than 2 ng/ml plasma at time of treatment, less than 1 ng/ml plasma on day 3 post-$PGF_{2\alpha}$ and greater than 2 ng/ml plasma on day 11 post-$PGF_{2\alpha}$.
[2] Progesterone levels not determined for cows of Treatment C.

gestational changes in normally cycling cows, plasma progesterone levels less than 1 ng/ml on day 3 and greater than 2 ng/ml on day 11 after prostaglandin treatment were considered to be "typical" changes.

The first heifer group was treated 2 weeks earlier than were the cows. Therefore, by the time the cows were treated, it was apparent that a large number of the heifers were not responding as expected. The most logical reason for this appeared to be that the heifers did not have a functional CL and were not cycling, even though there was some structure on the ovary that resembled a CL upon being palpated. It has been well established that for prostaglandins to result in estrus synchronization there must be a functional CL present. Therefore, one additional blood sample was collected from the cows at the time of palpation and treatment. If a functional CL was present, the blood levels of progesterone should be 2 ng/ml or higher. The "typical" progesterone level for cows was set at this value for the day of treatment and the same values as for the heifers on days 3 and 11.

When only the results obtained with cows and heifers showing progesterone levels typical of cycling animals with a functional CL are considered, the results are much more encouraging. There were 27 heifers determined to have typical progesterone levels at time of treatment; 26

(96.3 percent) exhibited an estrus within 8 days. In the case of the cows, 78.9 percent of the 19 cows with typical progesterone levels were in estrus at the expected time. The average time from treatment to occurrence of estrus was approximately 1 day longer in the cows than in heifers (2.35 days vs. 3.40 days).

The fertility data is also encouraging when the conception rates of animals of Treatment A that had typical progesterone levels are considered. This is the logical prostaglandin treated group to compare to the controls. In the heifer group the conception rates for the Treatment A heifers was 73.3 percent, very comparable to the 76.7 percent conception rate for the control heifers. In the case of the cows the conceptions were likewise almost identical, being 71.4 percent for Treatment A cows and 69.0 percent for control cows.

There were 41 heifers and 40 cows treated with $PGF_{2\alpha}$ that did not have typical progesterone levels, thus, were not considered to be cycling. Only six of these heifers showed signs of estrus following treatment and none conceived. In the case of the cows, only eight showed signs of estrus and two conceived.

Thus, data obtained in this study confirms that if the female has a functional corpus luteum at the time of treatment, prostaglandins will effectively synchronize estrus. It further suggests that normal fertility will be obtained from inseminations at the synchronized estrus.

The labor saving potential of Treatment B is readily apparent, since it would permit cows to be bred on a schedule and eliminate the necessity of checking for estrus. The results reported for the animals of Treatment B that had a typical level of blood progesterone revealed that 50.0 percent of the heifers and 36.4 percent of the cows conceived to the insemination made 80 hours after the prostaglandin injection. The cows would be expected to have a lower conception rate since an estrus following $PGF_{2\alpha}$ treatment was observed in only 72.7 percent of the cows compared to 87.5 percent of the heifers. The lower conception rates obtained in both age groups of females on Treatment B, when compared to Treatment A, can be very logically explained by the range in time of occurrence of estrus, 1-5 days for the heifers and 2-8 days for the cows. A range this wide would make it impossible for a single insemination to be given at a time that would guarantee that sperm of high fertilizing capacity would be present in all of the cows at the time ovulation occurred. It would appear that at least two inseminations would be required, most likely timed on either side of the 80 hours used in this study. Additional research is now being conducted to determine the optimum times for such "scheduled" inseminations.

This study points out very clearly one of the major problems involved in using prostaglandins to synchronize estrus in spring calving cows or yearling heifers being maintained under range conditions. When breeding is begun in late April or early May, a certain percentage of these females will not be cycling. If the producer cannot identify these non-cycling cows and heifers, but rather treats the entire herd he can expect a disappointing response to prostaglandin treatment.

In this study, 51 percent of the cows and 39 percent of the heifers were not cycling (Tables 2 and 3). Most of these were in Treatments A and B, but this should not be considered to be a result of the prostaglandin treatments. The design of the study created this situation by assigning to Treatment C all of the heifers that came in heat during the week prior to the start of prostaglandin treatment. Thus, all of the non-cycling females were in the group from which the animals for Treatments A and B were picked.

It was hoped that rectal palpations would screen out the animals that were not cycling by identifying those with a functional CL. It is now apparent that many of the non-cycling animals had some structure on the ovary that resembled a CL and misled the palpator. The nature of this structure was not determined, but it now appears that rectal palpations are not highly effective in screening cows for prostaglandin treatment if very many of the cows are not cycling.

How can a producer guarantee that all, or at least a high percentage of the females in his herd will be cycling at a given time? With lactating cows the two most important factors in most range herds are level of nutrition and length of the post-partum interval since calving. The closer cows are to 90 days post-partum, the more likely they are to be cycling. As the interval becomes progressively shorter than 90 days, level of nutrition becomes increasingly important. The importance of post-partum interval is shown by the data obtained in this study. The post-partum intervals for cycling Hereford and Angus cows were 75.8 and 75.5 days, respectively, and for non-cycling cows was 63.2 and 67.2 days, respectively.

In the case of yearling heifers, studies at Ft. Reno as well as at other stations, have revealed the importance of a good level of nutrition. Hereford and Angus heifers must be so fed that they will be weighing somewhere between 550 and 600 lb. at the time it is desired to start breeding. Large breeds such as the Brown Swiss or Simmental should have the same, if not higher, requirements. Early maturing, smaller breeds such as the Jersey are known to reach puberty at younger ages and lighter weights. The results obtained in this study supports the above observations. The average body weights, taken 2 weeks before the start of the study, were for cycling and non-cycling heifers, respectively: Hereford sired, 500 and 494 lb.; Angus sired, 492 and 453 lb.; Simmental sired, 571 and 530 lb.;

Brown Swiss sired, 530 and 481 lb.; and Jersey sired, 476 and 481 lb. The same relationship held for average age at the start of the study, but for both measurements the differences were not significant. The Jersey sired heifers had the highest percentage to have reached sexual maturity at the start of the study, 87.5 percent, compared to 69.2 percent of the Hereford sired, 48.0 percent of the Simmental sired, 45.8 percent of the Brown Swiss sired and 45.4 percent of the Angus sired heifers. Thus, as their body weights suggest, the level of nutrition that had been provided to all groups except the Jersey sired group were apparently too low to permit a high percentage of the heifers to reach sexual maturity.

Factors Affecting the Calving Interval in Large Dairy Herds

H. Slama, M. E. Wells and G. D. Adams

Story in Brief

Poor reproduction performance continues to cause major losses for many dariymen. Long calving intervals, loss of profitable cow time in the herd, fewer herd replacement animals and increased cost of the breeding program are among the major factors that take a tremendous cut out of a dairyman's potential profit.

Several factors can add significantly to the length of the period from one calving to the subsequent calving. Some of this time interval is dictated as being necessary for cow recovery postpartum. However, once the cows' reproductive system has recovered from the previous calving, man has his "management opportunity"—to get the cow back in calf as efficiently as his skill allows. This study, based on breeding, calving and production records of cows in the Oklahoma State University dairy herd for the years 1968 through 1974, was conducted to summarize the reproductive performance and determine the relative influence of several factors on the potential length of the calving interval.

The intervals from calving to first service and from first service to conception and the number of services per conception were significant

factors that determined calving interval. In Holsteins, there was an indication that cows with high peak milk levels would be somewhat more difficult to re-breed.

These factors indicate that the prime goals that a dairyman needs to strive for in achieving optimum calving intervals are (1) commence breeding when the cow has recovered from calving (50-60 days usually); a minimum number of services per conception and (3) if re-breeding is necessary, a minimum interval from first service to ultimate conception.

Introduction

As herd hize increases, it becomes increasingly more difficult to manage well the reproductive performance of a herd. High labor costs as well as the unavailability of labor causes dairymen to try to stretch their resources in order to manage the several facets of dairy herd operations. With the increasing competition for time, the calving interval has been gradually increasing in Oklahoma.

In order for a cow to achieve a long, economically productive life, high milk production and reasonable reproductive efficiency are necessary. Many dairymen have been able to increase production capability of their cows to a significant degree by using genetically superior animals. However, low reproductive efficiency seems to be a continuing, complex problem. It has long been recognized that low conception rate and the resulting long calving interval significantly lower the net returns from a herd. A twelve month calving interval is considered the ideal reproductive performance in achieving the optimum production potential from a herd.

The purpose of this study was to determine what factors affect calving interval and to relate the findings to potential improvement in management of reproductive efficiency.

Materials and Methods

All cows in the OSU dairy herd that had completed a lactation and calved subsequently between January 1, 1968 and March 3, 1974, were considered in this study. A total of 696 calving intervals on 370 cows were used (240 calving intervals on 131 Ayrshire cows, 315 on 161 Holsteins, 84 on 47 Jerseys and 57 on 31 Guernseys). The same manager was in charge of the herd for almost all of the study period.

The herd is managed so that the majority of the cows calve from July to January, with very few calving outside this period. This coincides with the greatest student demand for milk on the campus. This does create a problem with some cows having to be held open for longer than necessary periods of time in order to get them to calve at the desired time.

Cows are checked for heat at least twice daily and artificially inseminated by dairy barn personnel. Cows in heat in the morning are inseminated in late afternoon while those in heat in the afternoon are inseminated the next morning.

The following factors were analyzed within each breed to evaluate their possible effect on length of the calving interval:

Year of calving	Interval from calving to first service
Month of calving	Interval from first service to conception
Month of first service	Services per conception
Month of conception	Peak milk level
Age at calving	

Results and Discussion

Table 1 presents the conception rate data for each breed in the study. Overall, Ayrshire and Guernseys had lower breeding efficiency than did Holsteins and Jerseys (respectively 2.27 and 2.26 versus 1.95 services per conception). Table 2 also reflects the same idea in that approximately 90 percent of the Holsteins and Jerseys had settled by 3 services while only about 80 percent of the Ayrshires and Guernseys had settled to 3 services. The analysis of conception rate within service shows that the efficiency of conception to the remaining 4 services was quite variable within Ayrshires and Guernseys. Conversely, in Holsteins and Jerseys, a conception rate of 65 percent or better was apparent within any one of the services beyond third service. It should be pointed out that the overall reproductive efficiency of these cows would be quite low in that they had already been bred 3 times and failed to conceive.

Table 3 shows that there was a significant difference in the fertility level of bulls used in the different breeds, undoubtedly this contributed

Table 1. Services Required Per Conception and Percent Services Resulting in Conception During the Period 1968-1974.

BREED	Number of bulls	Number of cows	Number of conceptions	Number of services	Services per conception	Percent Services resulting in conception
Ayrshire	13	131	240	545	2.27	44.0
Guernsey	9	31	57	129	2.26	44.1
Holstein	33	161	315	613	1.95	51.3
Jersey	11	47	84	165	1.96	50.9
Overall breed	66	370	696	1452	2.10	47.9

Table 2. Number and Percent of Cows Conceiving at Each of A. Series of Consecutive Services.

ITEM	Services required per conception						
	1	2	3	4	5	6	7
AYRSHIRE							
Total services	240	134	81	50	27	10	3
Total conceptions	106	53	31	23	17	7	3
% conception	44.1	39.5	38.2	46.0	62.9	70.0	100.0
% of total conceptions	44.1	22.0	12.9	9.5	7.0	2.9	1.2
GUERNSEY							
Total services	57	30	16	11	9	5	1
Total conceptions	27	14	5	2	4	4	1
% conception	47.3	46.6	31.2	18.1	44.4	80.0	100.0
% of total conceptions	47.3	24.5	8.7	3.51	7.0	7.0	1.7
HOLSTEIN							
Total services	315	164	88	31	11	4	
Total conceptions	151	76	57	20	7	4	
% conception	47.9	46.3	64.7	64.5	63.6	100	
% of total conceptions	47.9	24.1	18.1	6.3	2.2	1.2	
JERSEY							
Total services	84	42	23	9	3	3	1
Total conceptions	42	19	14	6	0	2	1
% conceptions	50.0	45.2	60.8	66.6	0.0	66.0	100.0
% of total conceptions	50.0	22.6	16.6	7.1	0.0	2.3	1.1
OVERALL BREEDS							
Total services	696	370	208	101	50	22	5
Total conceptions	326	162	107	51	28	17	5
% conception	46.8	43.7	51.4	50.5	56.0	77.2	100.0
% of total conceptions	46.8	23.2	15.3	7.3	4.0	2.4	0.7

to the lower conception rate in the case of Guernseys and Ayrshires. Variations in insemination technique and less than optimum timing of insemination in relation to first observation of heat undoubtedly also contributed to lowered conception rate. Table 4 presents the breed means for calving interval, the interval from calving to first service and from first service to conception, services per conception, gestation length, peak daily milk production and 2X, M.E. 305 day milk production. The calving interval ranged from 396 days for Holsteins to 414 days for Guernseys, or, a range of 13.0 to 13.5 months. These are not excessively long intervals, but some improvement can be made.

Breed analyses indicated that approximately 60 percent of the variation in calving interval was due to variation among cows within each breed. Further, the analysis indicated that in Guernseys and Ayrshires, the interval from calving to first service and services per conception were major factors affecting the length of the calving interval. In Holsteins and Jerseys, which required somewhat fewer services per conception, the

Table 3. Distribution of Bulls Used According to Their Conception Rate.

BREED	Percent conception rate								
	Greater than 60			50 to 60			Less than 50		
	No. bulls	No. of services	% of services in breed	No. bulls	No. of services	% of services in breed	No. bulls	No. of services	% of services in breed
AYRSHIRE	2	26	4.7	6	218	40.0	5	301	55.2
GUERNSEY	3	20	15.5	2	36	27.9	4	73	56.3
HOLSTEIN	14	135	22.0	7	256	41.7	12	222	36.1
JERSEY	4	23	13.9	4	50	30.3	3	92	55.7

Table 4. **Overall Mean for Calving Interval, Calving to First Service, First Service to Conception, Services Per Conception, Gestation Length, Peak of Milk Production and 305 — Day Milk Production.**

ITEM	BREED			
	AYRSHIRE	GUERNSEY	HOLSTEIN	JERSEY
Calving interval (days)	400.6	414.1	396.1	401.8
Calving to first service (days)	83.1	90.7	84.8	84.2
First service to conception (days)	40.1	38.9	33.0	36.6
Services per conception	2.24	2.29	1.95	1.95
Gestation length (days)	277.5	285.1	278.2	280.9
Peak of milk production (lbs.)	54.3	47.7	64.8	41.2
305-day milk production (ls.)	13013.5	10610.3	15872.2	9138.3

intervals from calving to first service and from first service to conception significantly affected the calving interval. As would be expected, the services per conception and interval from first service to conception were highly correlated. Therefore, it can be stated, for all breeds, that the interval from calving to first service and services per conception are critical management areas for adjusting the length of the calving interval.

In Holsteins and Ayrshires, year of calving was of minor significance and there was a suggestion in Holsteins that peak level of milk production affected calving interval. However, this effect was relatively minor and did not appear to have any effect in the other breeds. The age of the cow, the month of the calving and month of conception had little or no effect on calving interval.

In summary, this study strongly points out that the prime areas where diligent management attention can have the greatest effect on calving interval are, (1) the interval from calving to first breeding and, (2) the number of services required per conception. The interval from calving to first breeding is dependent on several factors (records availablity, awareness of cow status and management needs peculiar to the herd). The efficiency of the insemination program can be affected by several factors. Research is in progress to study the interplay of cow factors, management decisions and insemination practices in achieving optimum reproductive performance from a herd of cattle.

Progesterone in Blood Plasma of Gilts During Early Pregnancy and During Exposure to Elevated Ambient Temperature

D.L. Kreider and R.P. Wettemann

Story in Brief

The causes of reduced reproductive efficiency in gilts during the summer months must be understood so improvements can be made through management and hormonal therapy. Two experiments were conducted to measure endocrine changes in gilts during early pregnancy and during exposure to elevated ambient temperature.

In the first experiment, indwelling cannulae were placed in the anterior vena cava and blood samples were collected once daily from 13 gilts until 29 days postbreeding. In 10 pregnant gilts, plasma progesterone increased linearly from 0.9 ng/ml on the first day of estrus (day 0) to 42.5 ng/ml on day 12 of pregnancy, then increased gradually to a maximum of 47.7 ng/ml by day 15. Progesterone then decreased sharply to 18.6 ng/ml on day 21 of pregnancy and remained near this level through day 29. Progesterone in the three open gilts increased linearly from 1.2 ng/ml on day 0 to a maximum of 32.9 ng/ml on day 12 post estrus, then decreased to 1.2 ng/ml by day 23 post estrus.

In the second experiment, 18 gilts were cannulated and allotted at random to either hot (95°F) or cool (74°F) environmental chambers for the first eight days following breeding. Blood samples were collected twice daily while gilts were in the chambers. During the eight days of confinement, plasma progesterone in cool gilts increased from 1.0 ng/ml on day 0 to 21.7 ng/ml by day eight. In gilts exposed to elevated ambient temperatures, progesterone increased from 1.4 ng/ml on day 0 to 25.4 ng/ml by day 8, and was consistently higher than in cool gilts. Three of nine gilts in the cool chamber conceived but only one of nine gilts in the hot chamber was pregnant at 30 days after breeding.

Introduction

Farrowing occurs during all months of the year in large-scale swine operations. Lower conception rates and smaller litters frequently occur during the months of high ambient temperature. Previous research at this station has demonstrated that heat stress of gilts during early pregnancy can cause a reduction in conception rate and in the number of pigs per litter at 30 days of gestation. However, little information is available on plasma hormone changes during early pregnancy or changes in endocrine function which may be caused by heat stress. An understanding of the endocrine alterations caused by heat stress may lead to the development of management or therapeutic methods to increase litter size in gilts.

Two trials were conducted during 1974. The first trial was designed to develop a technique for placing cannulae in the anterior vena cava of gilts to allow collection of blood samples without stress, and to establish normal hormonal changes which occur in gilts during the first 29 days of pregnancy. The objective of the second trial was to quantify endocrine alterations caused by heat stress during the first eight days of pregnancy.

Materials and Methods

In the first trial a technique was developed for cannulating gilts so blood samples could be collected without stress. Gilts were anesthetized with sodium thiopental and a cannula (silastic tubing .085 inches O.D., 48 inches length) was inserted into the anterior vena cava. About 12 inches of cannula were placed in the vein and the remainder was placed under the skin, using a trocar, and was exteriorized at the top of the back. Thirteen Hampshire x Yorkshire gilts were observed through at least one estrous cycle, and were cannulated at six to 12 days prior to the next expected estrus. Cannulated gilts were observed for estrus, using a boar each morning. The boar was allowed to breed gilts on the first day of estrus. Gilts were bled immediately after breeding and were placed in individual confinement stalls to facilitate collection of blood samples. Gilts were artificially inseminated on the second day of estrus and were subsequently bled once daily through day 29 post estrus or until cannulae were no longer functional. During the sampling period the environmental temperature in the barn ranged from 40° to 80° F. At 30 days post breeding, gilts were slaughtered and conception rate, embryo numbers, and corpora lutea numbers were determined.

In the second trial, 18 Hampshire x Yorkshire gilts were cannulated and observed for estrus as in the first trial. Cannulated gilts were bred naturally at 8 am on the first day of estrus and artificially inseminated on the morning of the second day. Gilts were bled immediately after the first breeding and were bled again at 8 pm of the same day. After the second bleeding, gilts were randomly assigned to confinement inside either the hot or cool environmental chamber. Each chamber contained two confinement crates. The hot chamber was maintained at 95° F from

8 am to 8 pm and at 90° F from 8 pm to 8 am. The cool chamber was maintained continuously at 74° F. Relative humidity was constant at 50 percent and all gilts received 12 hours of light (8 am to 8 pm).

During the eight days (days 1-8) of confinement in the environmental chambers, gilts were bled at 8 am and 8 pm each day while consuming feed. Gilts received approximately four pounds of feed per day (the maximum intake of hot gilts), and water was provided at chamber temperature by nipple waterers. Gilts were removed from the chambers after the second bleeding on day eight. Conception rate, embryo numbers, and corpora lutea numbers were obtained at slaughter at approximately day 30 after breeding. Plasma samples were stored at 0° F until progesterone was quantified by radioimmunoassay.

Results and Discussion

Conception Rate, Corpora Lutea and Embryo Numbers

In the first trial 77 percent of the gilts conceived, indicating that cannulation and confinement to the individual crates had no major effect upon conception (table 1). Average number of corpora lutea and embryos after day 30 were 13.2 and 13.0 respectively. Conception rates for gilts confined to the environmental chambers were 33 percent for cool gilts and 11 percent for hot gilts, indicating that some factor such as chamber noise or twice daily bleeding may have affected conception rate in both groups. However, three of nine cool gilts conceived while only one of nine hot gilts was pregnant at 30 days after breeding. Average numbers of corpora lutea and embryos were 13.7 and 11.3 respectively for the cool gilts, while corpora lutea number and embryo number for the one pregnant hot gilt was 13.0 and 8.0 respectively. Although conception rate was low in both groups, this data agrees with

Table 1. Conception rate, corpora lutea numbers and embryo numbers in cannulated gilts[1]

Treatment	Gilts	Pregnant	Corpora Lutea	Embryos
Experiment 1	(no.)	(no.)	(no.)	(no.)
Confined at swine barn (40-80° F)	13	10	13.2	13.0
Experiment 2				
Cool Environmental chamber (74° F)	9	3	13.7	11.3
Hot Environmental chamber (90-95° F)	9	1	13.0	8.0

[1] Cannulae were placed in the anterior vena cava six to 12 days before estrus and blood plasma was collected daily (Experiment 1) or twice daily (Experiment 2).

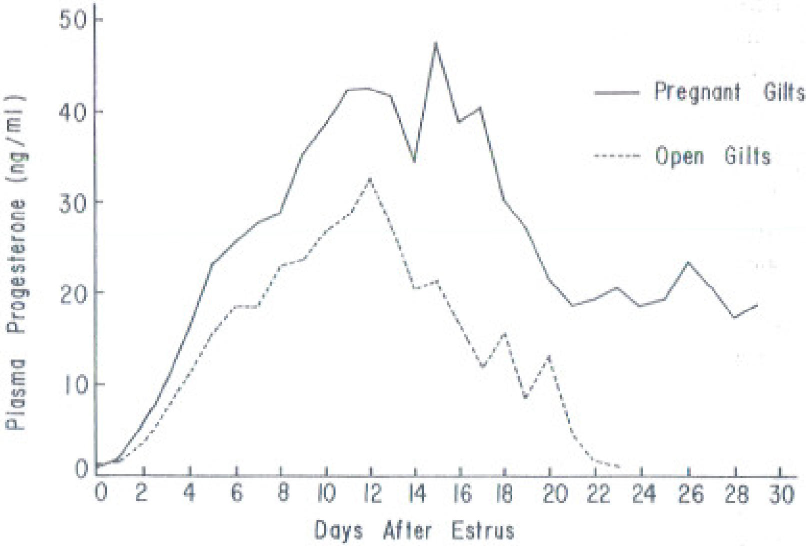

Figure 1. Plasma progesterone in pregnant (n=10) and open (n=3) gilts.

previous studies which demonstrated that conception rate and number of embryos at 30 days was higher in cool gilts than in hot gilts.

Plasma Progesterone

Plasma progesterone in the 10 pregnant gilts in trial 1 increased from 0.9 ng/ml on the first day of estrus to 42.5 ng/ml on day 12, and reached a maximum of 47.7 ng/ml on day 15. Progesterone then decreased sharply to 18.6 ng/ml on day 21 and remained near this level through day 29 of pregnancy. This reduction in plasma progesterone during early pregnancy is not observed in cattle. Plasma progesterone in cows during the early months of pregnancy is similar to the maximum observed during the luteal phase of the estrous cycle. In three open gilts, progesterone increased from 1.2 ng/ml on day 0 to 32.9 ng/ml on day 12, then decreased sharply to 1.2 ng/ml by day 23 post estrus.

Plasma progesterone was altered when gilts were exposed to elevated ambient temperature (figure 2). Progesterone in gilts placed in the hot chamber rose from 1.4 ng/ml on day 0 to 25.4 ng/ml on the second bleeding of day 8 post estrus. Similarly, progesterone levels in cool chamber gilts increased from 0.95 ng/ml on day 0 to 21.72 ng/ml on the second bleeding of day 8 post estrus. However, progesterone in hot gilts was consistently higher than in cool gilts, suggesting that high environmental temperature alters endocrine function in gilts. This alteration in endocrine function could be related to the reduced reproductive efficiency observed when gilts are exposed to elevated ambient temperatures during early pregnancy.

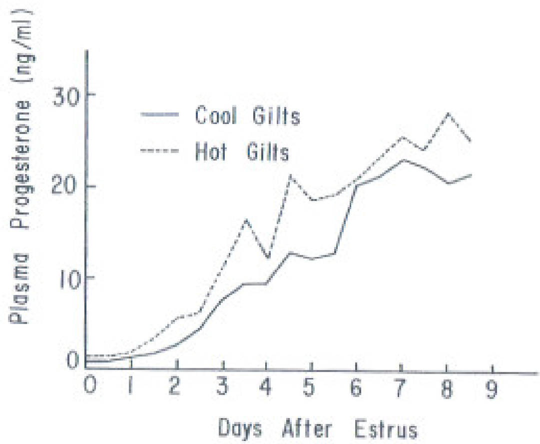

Figure 2. Plasma progesterone in gilts exposed to cool (74° F) or hot (95°F) environments after breeding.

Induction of Constant Estrus in Ovariectomized Sows

L. Brock, R.P. Wettemann and B. Taiwo

Story in Brief

Seven ovariectomized sows were treated with 12, 20 or 40 mg. of estradiol benzoate or 36 mg. of diethylstilbesterol to induce constant estrus. Within three days after treatment all sows were in standing estrus, and sows remained in estrus for 13 to 21 days after treatment.

Introduction

A problem frequently encountered in utilizing artificial insemination in swine is training boars so semen can be collected by the gloved-hand technique. Some boars will not mount a collection dummy, thus it would be convenient to have sows in constant estrus for the boar to mount during semen collection. Studies indicate that injection of prepubertal or ovariectomized gilts with estrogen will induce estrus. The objective of this study was to determine if commercially available implants, containing estrogen, could be utilized to induce estrus in ovariectomized sows.

Materials and Methods

Seven sows were ovariectomized one to three months prior to the start of treatment. Two sows were injected intramuscularly with 12 mg. of estradiol benzoate dissolved in corn oil. Commercially available growth stimulants were implanted into the ears of the other sows. Two sows were implanted with 36 mg. of diethylstilbesterol (DES), two sows were implanted with 20 mg. of estradiol benzoate and 200 mg. of testosterone propionate (Synovex H) and the other sow was given 40 mg. of estradiol benzoate and 400 mg. of progesterone (Synovex S). Sows were teased daily with a boar to determine the onset and duration of estrus.

Table 1. Estrous Activity of Ovariectomized Sows Treated with Estrogen

Treatment	Sow wt.	Estrus: Onset after Treatment	Estrus: Duration
	(lbs.)	(da.)	(da.)
Estradiol benzoate (12 mg.) in corn oil	275	3	21
	325	3	15
Diethylstilbesterol (36 mg.) implant	315	3	15
	390	2	20
Estradiol benzoate (20 mg.) and testosterone propionate (200 mg.) implant	365	2	13
	440	3	15
Estradiol benzoate (40 mg.) and progesterone (400 mg.) implant	240	3	20

Results and Discussion

Estrus was induced in all sows within three days after treatment (table 1). Estradiol benzoate and DES appear to have similar effects on the induction of estrus in ovariectomized sows. The addition of progesterone or testosterone propionate to the implant did not inhibit the ability of estradiol to cause estrus. Although estrogen should still be present and released from the implants at three weeks after treatment, the sows no longer exhibited standing estrus.

When progesterone is present in large quantities, it inhibits the ability of estrogen to cause standing estrus in sows. Therefore, treatment of sows with estrogen during the estrous cycle will not cause the induction of estrus, but if anestrous gilts are injected with estradiol benzoate, estrus occurs.

Testicular Characteristics of Duroc, Hampshire and Cross-Bred Boars at 7.5 Months of Age

J. Holzler, R. P. Wettemann, R. K. Johnson and S. Welty

Story in Brief

Fifty-four boars of Duroc (D), Hampshire (H) and DxH breeding were castrated at 7.5 months of age to determine if breed influences testicular development. Testes, capita-corpora epididymides and caudae epididymides were weighed and homogenized and sperm numbers were determined by microscopic count. Breed of boar did not influence significantly testes or epididymidal weights or sperm numbers. Although these young boars had about 90 percent as many testicular sperm as mature boars they had only about half as many epididymidal sperm as mature boars.

Introduction

Age to puberty is a major factor that influences an animal's ability to be used in a breeding program. Numerous studies have been reported on sexual development and reproductive performance of gilts, but information related to pubertal development of boars is limited.

Much information is available on crossbred gilts and they are recommended in many commercial breeding programs. However, little information is available on the effects of crossbreeding on reproductive development of boars. The objective of the present study was to determine if crossbreeding influences the numbers of testicular and epididymidal sperm near puberty in boars.

Materials and Methods

Sixteen Duroc, 11 Hampshire and 27 crossbred (DxH, HxD) boars were castrated at approximately 7.5 months of age. About half of the boars of each breed were castrated in the Spring of 1974 and the other half were castrated in the Fall of 1974.

Testes, capita-corpora epididymides and caudae epididymides were weighed and homogenized in physiological saline with 0.05 percent Triton X-100 and 100 ppm merthiolate added. Sperm numbers in the epididymides and the testes were determined microscopically using a hemacytometer.

Results and Discussion

None of the reproductive criteria measured was altered significantly by the season that the boars were castrated. Breed of boar did not influence significantly the testes or epididymidal weights (table 1). But testes from crossbred boars tended to be heavier (669.5 g) than those from Duroc (598.4 g) and Hampshire boars (642.3 g). These weights are about 70 percent of the average that we have observed in mature boars.

Sperm numbers in the epididymides and testes were not affected by breed of boar. Total testes sperm in these young boars was about 90 percent of the number that we have observed in mature boars. However, there were only about half as many epididymidal sperm in these young boars compared to the number found in mature boars. After sperm are formed in the testes they are transported to the epididymides where maturation occurs during a 10 to 14 day period before they are ejaculated Therefore, young boars may have testes sperm numbers similar to mature boars, but they are not fully sexually developed because less sperm are undergoing maturation in the epididymides.

Table 1. Gonadal and Epididymal Weights and Sperm Numbers in 7.5 Month-Old Boars

Criteria	Breeds		
	Duroc	Hampshire	DxH
Boars (no.)	16	11	27
Testes Wt. (g)	598.4 ± 31.4[1]	642.3 ± 37.8	669.5 ± 24.1
Total Testes Sperm ($X 10^9$)	110.9 ± 30.1	75.2 ± 36.3	88.2 ± 23.2
C-C[2] epididymal wt. (g)	89.8 ± 4.6	92.2 ± 5.6	87.7 ± 3.6
C-C epididymal sperm ($X 10^9$)	58.7 ± 6.6	78.2 ± 8.0	67.8 ± 5.1
Caudia epididymal wt. (g)	85.5 ± 4.18	82.7 ± 5.0	94.6 ± 3.2
Cauda epididymal sperm ($X 10^9$)	125.2 ± 13.8	100.6 ± 16.6	127.5 ± 10.6

[1] Means ± Standard errors.
[2] Capita-Corpora.

Summary Reports

Milk Flavors

J. B. Mickle, M. S. Borges, and R. D. Morrison

Much of this research on milk flavors and cows' feed energy was reported last year (MP-92, p. 278). Final analysis of the data showed two additional findings.

None of the changes made in the cow's feed or daily routine caused all animals in the group to react in the same manner. These changes included underfeeding and changing the animal's hay to grain ratio. They also involved violent exercise immediately before milking, getting the cow out of her normal place in the milking line, and changes in weather conditions. In all cases the cows reacted as individuals to these changes. Thus, when flavor difficulties arise in a milking herd, one should not expect that the whole herd has trouble, i.e., changing feeds may cause undesirable flavors in the milk of one cow while the one beside her may have no trouble at all with her milk flavor.

If flavor troubles persist in a herd's milk, the only solution is to taste the milk of each cow individually, and remove those cows from the milking line which have undesirable flavors. Milk from the remainder of the herd can be collected and sold. The effects of feed changes on milk flavor are usually short lived, providing the cow is healthy. Thus, if a cow has to be removed from the milking line because of flavor troubles, it is quite probable that this individual will adjust herself to the change within two or three days. She then can be put back in the milking line and her milk sold as usual.

A second observation from these data was that milk nearly always tastes acceptable if tasted immediately after milking. Of the 240 milk samples tasted during this experiment, only 7 percent of these (18 milk samples) showed any flavor defects when the milk was fresh. The 18 samples with undesirable milk flavors came from two or three cows. Had their milk been removed from the tank, no undesirable flavor could have been deteched during the first 12 hours after milking. On the other hand, after the milk samples had been stored in the refrigerator for three days, additional milk samples developed "off-flavors". What this means, is that there is a slight flavor defect in the milk, it cannot be detected at first, but over time this flavor becomes worse. Thus, it is undesirable that a tank of milk may taste normal when fresh on the farm, but have an unacceptable flavor by the time it reaches its destination at the milk plant three or four days later.

One must remember that in this work we are trying to upset the cows and cause undesirable milk flavors. Over 40 percent of our samples had off-flavors after three days storage, such high percentages never happen under normal herd conditions. Thus, even when flavor difficulties occur, one would expect that only a few animals are causing the difficulty. The problem is, that if the milk from these animals is put in the tank with the rest of the good milk, it will eventually spoil the flavor of the whole tank. If those few animals with undesirable milk flavors could be handled in such a way that their milk does not go in the good milk, many of the tanks of milk which now are rejected because of milk flavors, might be salable.

Table 1. Number of Cows Whose Milk Had Various Flavor Changes When Samples Held at 5° from 12 to 72 hours.

FLAVOR CHANGE[2]		GROUP I — PERIOD AND TREATMENT[1]				
12 hr.	72 hr.	1-N	2-L	3-N	4-N	5-N
F	F	8	13	18	12	6
F	O	8	15	8	14	5
F	C		5	3	5	
F	R		2	2	2	1
C	O					
C	C	2	1			
R	R			3	3	3
		GROUP II — PERIOD AND TREATMENT				
		1-N	2-N	3-N	4-L	5-N
F	F	12	14	12	13	12
F	O		4	9	5	
F	C		3	1	3	
F	R					
C	O					
C	C		3	2		
R	R					

[1] Group I contained six cows, periods 1 and 5 included 3 days, periods 2, 3, and 4 included 6 days. N = "normal" ration with 100% of NRC energy requirements; L = "low" ration with 80% of NRC energy requirements. Group II contained only 4 cows.
[2] Flavor code: F = feed, O = oxidized, C = cowy, R = rancid.

Problems Associated With Induced Superovulation and Superfetation in Beef Cows

E. J. Turman, D. M. Hallford, R. P. Wettemann and C. E. Pope

Research continued on the use of the gonadotropic hormone preparation, pregnant mare serum or PMS, to induce multiple births in beef cows. Studies conducted during the past year were largely of a very basic nature and all analyses are not yet completed and summarized.

The study involved 31 lactating 3-year-old Angus cows and 23 non-lactating 2-year-old Angus heifers. Twelve heifers and 15 cows received a sequence of 2 subcutaneous PMS injections, 1500 IU on day 5 and 2000 IU on day 17 of the cycle, and 11 heifers and 16 cows received a single injection of 2000 IU PMS on day 17. Blood samples were taken from each animal on days 1, 3, 5, 6, 7, 9, 11, 13, 15, 17 and daily until estrus occurred. They were bred by natural service to Angus bulls at the post-PMS estrus. Ovulation rates were determined by means of a high lumbar laparatomy performed 7 to 11 days after estrus.

Estrus occurred following the PMS injections in 75.0 percent and 63.6 percent of the cows and heifers, respectively, that received the single injection of PMS, with ovulation rates being, respectively, 2.25 and 3.09 eggs. In the animals receiving the sequence of 2 PMS injections, estrus was observed in 66.7 percent and 100 percent of the cows and heifers, respectively, with ovulation rates being, respectively, 1.27 and 4.35 eggs.

Conception rates to natural service at the post-PMS estrus were: for animals receiving a single PMS injection, 62.5 percent for the cows and 45.4 percent for the heifers; for animals receiving the sequence of 2 PMS injections, 60.0 percent for the cows and 75.0 percent for the heifers. It was not possible to determine why the heifers performed best on the sequence of two injections while the cows performed best on the single injection.

The blood samples were centrifuged immediately following each bleeding, and the plasma frozen and stored until determination of levels of progesterone, estrogens and LH could be made by radioimmunoassay. These are now being completed and will be presented at a later date. It is anticipated that a consideration of the changes in the blood levels of these hormones will provide a better understanding of the physiological mechanisms involved in the response of cows to PMS.

In cooperation with USDA, Agricultural Research Service, Southern Region.

Use of the Emme as a Measure of Leanness in Swine

Dennis M. Stiffler, Lowell E. Walters, R. K. Johnson and Richard F. Queener

A precise, non-destructive measure of leanness in living meat animals would be a valuable aid in the selection of breeding as well in market animals as the livestock industry moves generally toward the production of animals that will provide a leaner meat product at the retail counter.

Recent interest in an evaluation technique utilizing the electronic properties of lean and fat as a basis for predicting leanness has provided such a possibility in the EMME (Electronic Meat Measuring Equipment). This method employs the principle that lean conducts electrical energy more readily than fat. In this instrument, an electronic transducer is so designed as to produce as electromagnetic field surrounding the chamber through which the animal is passed for evaluation. Differences in the amount of electromagnetism absorbed form the basis for the interpretation of results.

Forty-one market weight hogs, representing 3 breed crosses produced at the Fort Reno Livestock Research Station, were used in this follow-up study. The hogs were taken off-feed for 24 hours and washed prior to EMME evaluation. Each barrow was randomly counted five times for 2 purposes: (1) to provide data from which a determination of the repeatability of the device can be made, and (2) to determine the relationships between mean EMME count and pounds of fat-free lean from the carcass right half as determined by physical separation and chemical analyses.

Routine carcass data were obtained prior to cutting the right sides of each carcass into standard wholesale cuts. Untrimmed and closely trimmed cut weights were recorded from the four major wholesale cuts. The ham, loin, shoulder and thin cuts (belly and feet) were physically separated into lean, fat and bone. Ether-extract analyses were conducted on blended samples from the separable lean and pounds of fat-free lean were calculated by difference.

The analysis of the data is incomplete to date. However, the raw data appears to be no more promising than those of a previous study involving the EMME as a predictor of leanness in market hogs. The repeatability of the instrument and the relationship of the mean EMME count to different measures of leanness both appear to be somewhat inadequate for use in a meaningful prediction equation. A graphic plot

EMME count and fat-free lean. A more detailed report of the findings will be presented upon completion of the analysis of the data.

Net K^{40} Count as an Estimator of Lean in Two Types of Cattle Evaluated at Four Different Weights

Lowell E. Walters, Dennis M. Stiffler and R.F. Queener

Studies dealing with the relation between net K^{40} count and pounds of fat-free lean from steers of 2 different types slaughtered at 500, 700, 900 and 1100 pounds described in Oklahoma Agricultural Experiment Station Publication Number MP-92 (1974) continue in progress. The work is currently in the third and final replication. While the data to this point suggest certain trends, a report on this, the basic objective of the study, will not be made until all of the data are collected and analyzed.

Of added interest and as a "spin off" of the primary study are trends in the data relative to differences in muscling between the 2 types of cattle used in the work, namely "intermediate" or conventional type beef cattle and "growthy", large scale type. Table 1 presents the fat-free lean yields by type and slaughter weight. While the numbers of cattle involve to date are small, the advantage in yield of muscle in the "growthy" cattle used in the study appears to be quite pronounced. In addition to total muscle, certain muscles and muscle systems in the carcasses were removed individually from the carcass and weighed.

It appears from a preliminary review of the data that the "Growthy" type carcasses were especially meatier in such muscles as biceps femoris (outside of bottom round), semimembranosus and adductor (inside or top round), quadraceps (sirloin tip), longissimus dorsi (rib eye), psoas major (tenderloin) and semitendinosus (eye of round). With such variation in these and other economically important traits in our herds, it becomes important to the producer to combine in one production unit the best combination of reproductive performance, rate and efficiency of growth and fattening to market weight and of carcass merit.

So long as there is variation in these economically important traits we can make progress toward achieving these herds or individuals that will allow for the maximizing of beef production, and best fitted for one of a variety of environmental conditions under which beef production is accomplished.

Table 1. Mean Slaughter Weights and Yields of Fat-free Lean from Cattle of Different Types[1]

Conventional Beef Type			Growthy (Large Scale) Beef Type		
Slaughter Wt. Lbs.	Fat-free Lean Lbs.	Fat-free Lean % (Sl. Wt.)	Slaughter Wt. Lbs.	Fat-free Lean Lbs.	Fat-free Lean % (Sl. Wt.)
502	167	33.3	520	197	37.8
698	214	30.6	701	252	35.9
904	272	30.0	902	291	32.3
1095	302	27.6	1100	345	31.4

[1] 8 animals per weight group.

Serum Alkaline Phosphatase Levels in Small Scale and Large Scale Steer Calves

T.R. Kramer, J.R. Escoubas, J.J. Guenther and K.K. Novotny

The role of alkaline phosphatase in the production and growth of bone has been extensively investigated in humans and experimental animals but not in beef cattle. Alkaline phosphatase is particularly abundant in bone forming cells (osteoblasts) and in the formation and development of bone (osteogenesis). During recent years the beef industry has moved towards increased use of large scale beef cattle as sources of red meat. Limited information is available concerning the physiological growth patterns of bone, muscle and fat in these large scale or "exotic" breeds. This study is aimed at determining the relationship between serum alkaline phosphatase levels and bone maturity.

The experimental units for this study were eight grade Angus steer calves and eight crossbred Charolais (7/8 Charolais x 1/8 Angus) steer calves. Blood samples were collected from the calves at about one month of age and 56 day intervals thereafter, for a total of eight periods. The calves averaged 116 pounds in live weight at the first period. The Bessey, Lowry and Brock assay for the rapid determination of alkaline phosphatase or "alkaline phosphatase activity" of serum, was used. Results were expressed as micromoles of p-nitrophenol liberated per hour per milliliter of serum, which is the same as Sigma Units or Bessey-Lowry-Brock Units.

The mean values for the serum alkaline phosphatase results are given in Table 1. Results showed that the small scale Angus calves averaged 4.5 micromoles of alkaline phosphatase activity for the eight test periods, whereas that of the large scale Charolais was 5.3 micromoles. It may be perceived from the values in Table 1 that considerable variation existed in alkaline phosphatase activity among animals and periods. It is believed that much of the variation observed in alkaline phosphatase activity was due to stress of the animals during sampling.

From physiological growth patterns it would be expected that the large scale, late maturing Charolais would be expected to have a greater alkaline phosphatase level than the small scale, early maturing Angus. Also, the alkaline phosphatase levels should decrease with age. The data in Table 1 tend to support these expectations, but only from a general standpoint. However, it is believed that if the animal stress during sampling could be minimized, thus reducing variation, then alkaline phosphatase activity could be used as a measurement of the rate of bone growth and/or maturity.

Table 1. Alkaline Phosphatase Activity in Small Scale and Large Scale Calves.[1]

	Periods								
	1	2	3	4	5	6	7	8	Average
Angus	5.4[2]	7.1	3.7	2.7	5.4	4.7	4.1	3.1	4.5
Charolais	5.5	5.6	5.8	5.1	5.0	4.8	5.3	5.3	5.3

[1] All values are in a micromoles per hour per milliliter of serum.
[2] Each value represents the average of eight animals (determinations were in triplicates).

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Beef Carcass Composition Studies Among Crossbred Cattle

Dennis M. Stiffler, Lowell E. Walters and Richard R. Frahm

Crossbreeding in beef cattle has attracted a great deal of interest during recent years as producers search for methods of improving the production potential of their herds in terms of those traits of greatest economic importance. Many so-called "exotic" breeds are becoming more widely used in such attempts without the knowledge of the extent to which this new genetic material will contribute to such a program of maximizing quality beef production.

As a part of the recently initiated beef crossbreeding project at the Oklahoma Agricultural Experiment Station, studies are being initiated which deal with such beef carcass characteristics as quality grade, cutability, conformation grade, yield of total closely trimmed lean, fat and bone as well as the yield of certain selected individual muscles and muscle systems. In addition, Warner-Bratzler Shear values for tenderness determination will be obtained.

These studies are in the initial stages and the first group of cattle has been slaughtered, the carcasses evaluated and the data collected. Further reports will be made as sufficient data accumulate to warrant a detailed account of the findings.

The Effects of Freezing and Thawing on Lactate Dehydrogenase Isoenzymes from Bovine Muscle

J.R. Escoubas, J.J. Guenther and K. K. Novotny

Defining meat animal growth potential and muscle deposition efficiency has been the objective of meat scientists for several years. Many methods of ascribing muscling potential are being utilized today, however none of these takes into consideration metabolism at the fiber level, on the state of cellular metabolism, the state of cellular differentiation and the way these two parameters affect overall muscle synthesis and deposition would certainly assist in making finite determinations of muscling potential, a bovine growth and development investigation at the cellular and subcellular levels was initiated.

At the advent of such an extensive investigation, procedural format was developed. Of specific consideration was in what physical state should enzymic preparations be made so that *in vivo* functioning might be most accurately approximated? In order to define the state in which the tissue should be used, Lactate Dehydrogenase (LHD), a tetrameric, glycolytic enzyme was used. LHD catalyzes the reduction of pyruvate to lactate in order to generate reducing equivalents (NAD) for glycolysis during anaerobiosis. This enzyme is composed of two pure forms, the muscle type and the heart type which have a greater specificity for pyruvate and lactate, respectively. LHD-pyruvate specific has been observed primarily in tissues obtaining their energy mostly from glycolysis whereas LDH-lactate specific has been observed primarily in tissues obtaining their energy from aerobic pathways. Hybrids of these two pure forms occur in varying numbers and concentrations depending upon the energy substrates present. Quantitation of these forms of LDH and their relative concentrations would aid in defining the metabolic condition of the muscle tissue in question.

For this work muscle tissue was collected from bovine longissimus dorsi and portions were either frozen in liquid nitrogen or utilized as fresh tissue. The muscle sample was extracted, centrifuged and the resulting supernatant dialyzed and electrophoresed on polyacrylamide gels. These gels then were stained via dehydrogenase staining techniques. Bands were sectioned from unstained gels and enzyme and protein assays performed on each of the isolated band solutions. Enzyme activity was measured as the average optical density change per minute and expressed as units of enzyme activity per gram of muscle protein. These units were then expressed as a percentage of the summed activities of the sectioned bands.

The results as noted in Table I indicate a "hybridization" after freezing and thawing of the two original bands isolated in the fresh extract. These results are similar to those results of Blonde *et al* (1967) in their freeze-thawing experiments with Malate Dehydrogenase. Similar studies have been reported on LDH by Chilson *et al* (1965a), Chilson *et al* (1965b) and Chilson *et al* (1966). Investigations by Markert (1963) suggest that freeze-thawing two electrophoretically distince forms of LDH caused formation of multiple forms to appear in a binomial type of distribution. This author disclosed that such hybridization occurred via complete dis-

Table 1. Number and Percent of Lactate Dehydrogenase Bands at Various Extraction Periods.

Extraction Time	Fresh	Days Frozen						
		1	7	14	21	28	35	42
Number of Bands	2	2	3	4	4	4	4	4
Percent Activity: Band 1	35[1,2]	40.0[2]	35	28[2]	24[2]	14[2]	36[2]	50[2]
Band 2	65[3]	59.9	27	19	34	33	10	18
Band 3		60.0[3]	38[3]	31	25	32	28	22
Band 4				22[3]	17[3]	21[3]	26[3]	10[3]

[1] All values expressed as a percent of the summed specific activities of the gel sections.
[2] The band electrophoresing to the anode least rapidly labeled band 1 referred to as the muscle type.
[3] The band electrophoresing to the anode most rapidly was referred to as the heart type.

sociation and random recombination of subunits during the freezing and thawing process but offered no mechanistic explanation.

As indicated by the data in Table 1, electrophoretic separation and subsequent enzyme assays on the fresh muscle extract showed evidence of two isoenzyme bands. Yet after 7 days of storage at –20° C, three bands appeared indicating a possible hybridization of the two primary bands. By the 14th day of storage at –20° C, four isozymic bands appeared, possibly due to the same hybridization phenomenon. This information suggests that isoenzymic analysis on previously frozen muscle tissue might be subject to procedural artefacts and conclusions on such data would prove extremely hazardous. Thus, it was concluded that fresh muscle tissue must be utilized in all protein and enzymic assays in order to obtain results more indicative of the *in vivo* metabolic state.

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