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The Effect of Frequency of Feeding on Adaptation of Ruminants to Biuret as an NPN-Source

E. T. Clemens and R. R. Johnson

Story in Brief

Two trials were conducted to measure the biuretolytic activity of roughage fed ruminants supplemented with biuret at intervals of 1, 2 or 4 days. Rumen contents were collected from each animal at various days before and after supplementation over a 33 day test period for determination of the ability to break down biuret (biuretolytic activity).

Animals receiving the biuret daily or every 2 days were able to develop and maintain high levels of biuretolytic activity throughout both trials. Those animals supplemented every 4 days could neither develop nor maintain biuretolytic activity over the extended feeding intervals. It was concluded that as an NPN supplement for wintering ruminants on range grass, biuret would have to be fed at least every other day.

Introduction

The cost of protein supplementation for winter range cattle in Oklahoma has drawn attention to the possible use of non-protein nitrogen (NPN) sources to meet these needs. Biuret is one form of NPN presently under investigation. Like other NPN sources, biuret must be broken down to ammonia by the rumen microorganism prior to being utilized. Previous research has shown that an adaptation period is required for this ability to break down biuret can develop and this adaptation period is variable depending on the ration.

Furthermore, as soon as biuret is removed from the ration the ability to break down biuret (biuretolytic activity) is quickly lost. Some cattlemen follow the practice of only providing protein supplements once or twice a week during winter range feeding. If biuret is to function as an NPN supplement, the animals must first develop sufficient biuretolytic activity and, secondly, must maintain this activity during the wintering period. The trials reported here were designed to investigate the effects of frequency of feeding on the development and maintenance of biuretolytic activity.

Methods and Materials

Two experiments were designed to study the biuretolytic activity of the rumen microorganisms when biuret was supplmented to roughage fed ruminants at intervals of two and four days as compared to daily feeding.

Trial 1.

Poor quality prairie hay was fed free choice to 9 rumen cannulated sheep. The animals were placed in groups of 3 with each group receiving biuret supplement at either 1, 2, or 4 day intervals, at the levels indicated in Table 1. The trial was conducted for a 33 day test period, with rumen samples being collected on days 0, 2, 4, 8, 12, 16, 24 and 32 to observe the biuretolytic activity just prior to the days feeding. Additional samples were collected on days 5, 9, 13, 17 and 33 to observe the activity the day following biuret supplementation.

Each rumen sample was mixed with a biuret solution and incubated in a water bath (39°C) for 24 hours. The extent of biuretolytic activity was then determined by measuring the disapparance of biuret from each sample after 8 and 24 hours of incubation. High biuretolytic activity was indicated by a more rapid and complete disappearance of biuret.

Trial 2.

For this experiment 6 rumen cannulated steers were preadapted to biuret prior to the initiation of the experimental period. After sufficient biuretolytic activity was established in all animals, the steers were grouped such that some continued to receive daily supplementation while others received supplement every 2 or every 4 days at the levels indicated in Table 1. In this manner we were able to measure the animals ability

Table 1. Levels of feeding and frequencies of feeding biuret supplment in Trials 1 and 2.

Frequency of Feeding	Level of supplement, grams		
	Daily	Every 2 days	Every 4 days
Trial 1	160	320	640
Trial 2	1660	3320	6640

to maintain the biuretolytic activity over the extended feeding intervals. Daily feeding of poor quality prairie hay was continued for all animals throughout the entire test period. Rumen samples were collected from each animal on days similar to those in experiment 1, for laboratory analysis.

Results and Discussion

In the first trial little or no biuretolytic activity could be detected in the animals before the initiation of the biuret feeding (Figure 1, day

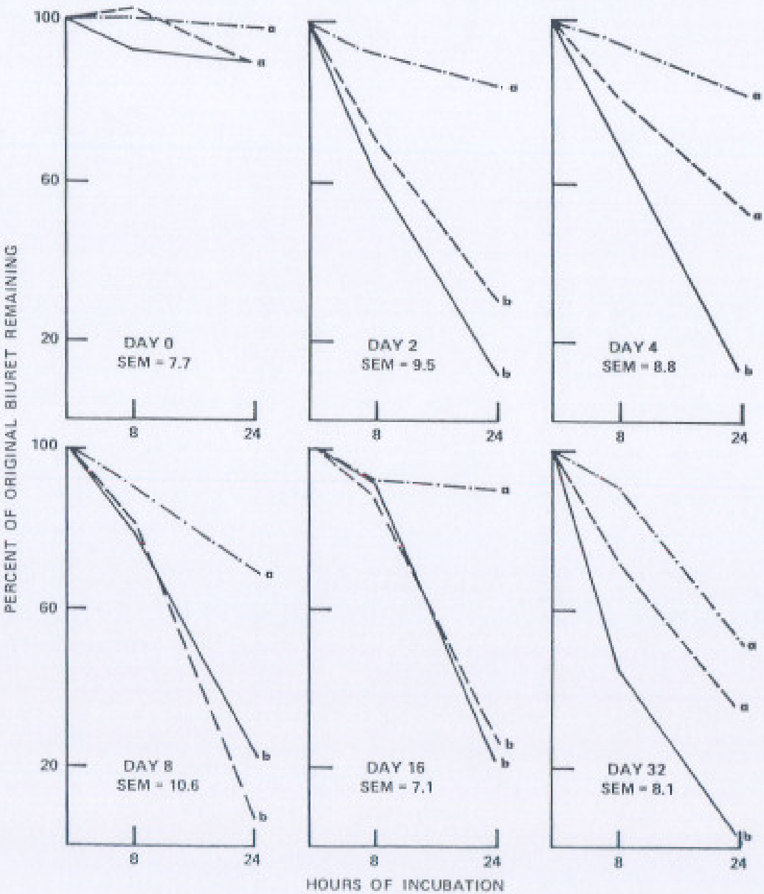

Figure 1. Biuret disappearance in rumen contents from sheep fed biuret supplement daily (___), every 2 days (_ _), or every 4 days (_._). Samples taken just before the days feeding— trial 1.

0). However, on day 2 those animals receiving biuret supplement daily or every 2 days revealed substantial biuretolytic activity, while minimal activity was observed for those fed every 4 days. Similar results were observed throughout the remainder of the experimental period, for rumen samples collected just prior to the days' supplementation. In samples of rumen liquor collected the day following biuret supplementation (Figure 2) the biuretolytic activity in animals fed biuret every 2 days was equal to that in animals supplmented daily. Those animals receiving supplement every 4 days failed to demonstrate any increase in activity.

For the second trial all animals were pre-adapted to biuret before the start of the trial (Figure 3, day 0). At this point the variation in the frequency of feeding program began. No differences were detected after 2 days; however, by day 4 a marked difference was observed. Those steers receiving the daily supplementation maintained a high level of biuretolytic activity. Those receiving supplement every 2 days appeared to have lost a portion of their activity, and those receiving supplement every 4 days lost nearly all of their biuretolytic activity over the extended feeding intervals.

When rumen samples were collected the day following supplementation the animals supplemented daily and those supplemented every 2 days showed comparable biuretolytic activity. The animals fed biuret

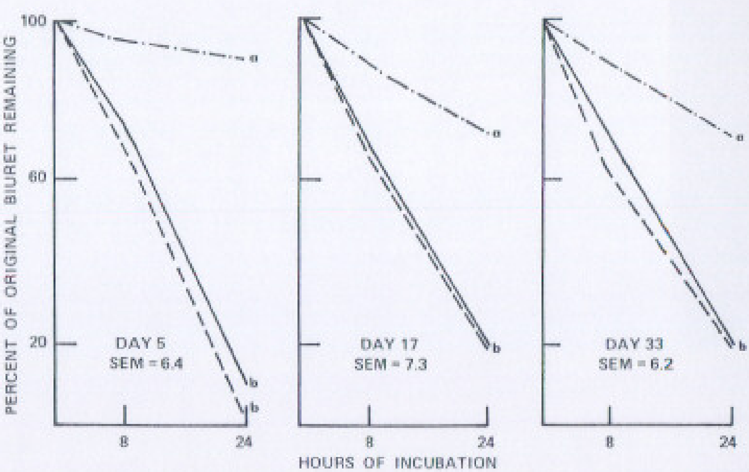

Figure 2. Biuret disappearance in rumen contents from sheep fed biuret supplement daily (___), every 2 days (_ _), or every 4 (_._). Samples taken the day following supplementation —trial 1.

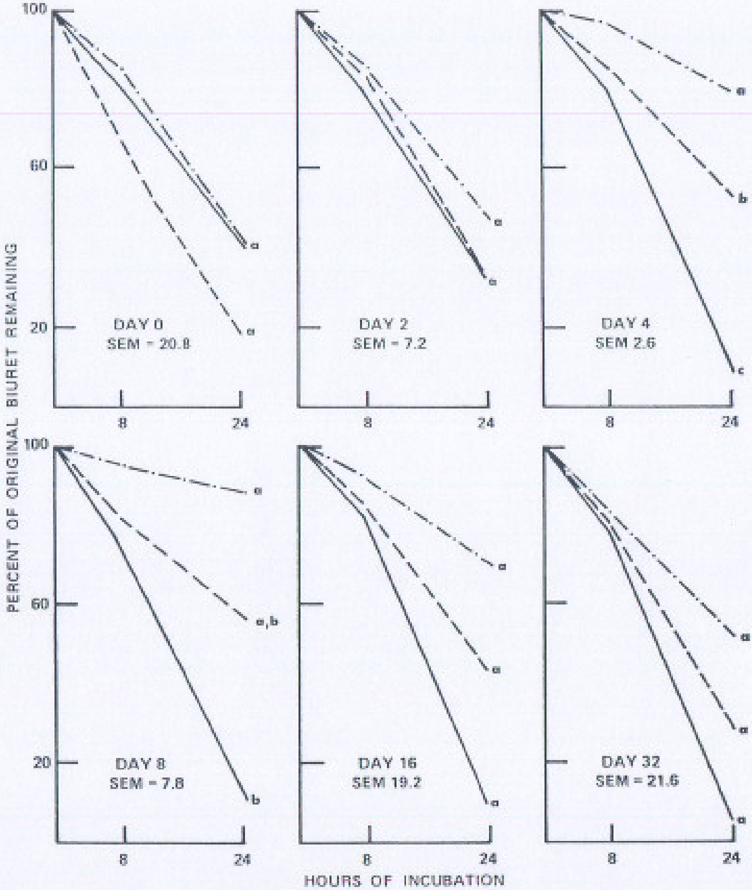

Figure 3. Biuret disappearance in rumen contents from steers fed biuret supplemnt daily (___), every 2 days (_ _) or every 4 days (_._). Samples taken just before the days feeding—trial 2.

every 4 days again failed to demonstrate an increase in biuretolytic activity.

From the results of these trials it would appear as though supplementation of winter range cattle with biuret daily or every 2 days would by satisfactory in developing and maintaining adequate biuretolytic activity to meet the protein needs of these animals. On the other hand, if biuret is fed at intervals of 4 days or greater the rumen microorganisms could neither develop nor maintain sufficient biuretolytic activity to degrade biuret to NH_3 rapidly enough to support microbial protein syntheses.

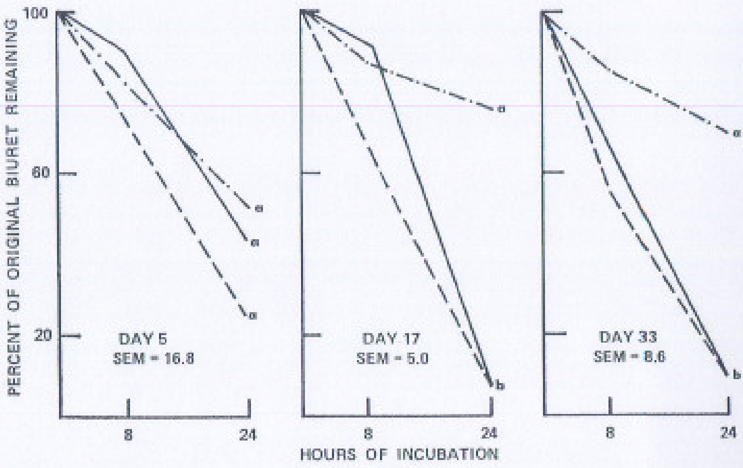

Figure 4. **Biuret disappearance in rumen contents from steers fed biuret supplement daily (___), every 2 days (_ _ _), or every 4 days (_._). Samples taken the day following supplementation—trial 2.**

Studies on the Nutritive value of Wheat Pasture

R. R. Johnson, M. McGeehon, E. Williams[1] and H. C. Young, Jr.[1]

Story in Brief

Although wheat pasture constitutes a major source of winter pasture, its chemical composition and nutritive value have not been thoroughly studied. Samples of wheat pasture were harvested at several dates over a 2 year period and analyzed in the laboratory. They were fairly high in cell wall constituents but low in lignin suggesting these cell wall fractions were highly digestible. Wheat pasture varied from 9 to 25 percent soluble carbohydrate which is 100 percent digestible. The samples were all high in crude protein, averaging 29 percent, of which a significant portion was present as non-protein nitrogen.

Introduction

In Oklahoma, wheat along with other small grains constitutes a major source of winter pasture for both cattle and sheep. Rather remarkable performances in terms of growth rates have been reported indicating this material has a high nutritive value. Strangely enough, however, investigations of the ability of small grain pasture to satisfy specific nutrient requirements have not been made nor have the influences of factors such as season, variety, temperature variations and rust infections been studied. The results reported here are from a combined effort to study chemical changes in plant tissue associated with leaf rust infection and chemical constituents associated with nutritive value for the ruminant animal. Only the latter objective will be reported at this time.

Methods and Materials

During the 1970-71 season, wheat samples were harvested on 4 dates from the experimental plots at Goodwell, Oklahoma. A total of 10 samples were obtained each date, the samples representing 5 genetic lines in the sprayed (for leaf rust) and unsprayed condition. Ten samples representing 5 genetic lines were also harvested on Oct. 15 and Nov. 19, 1971, from Stillwater plots. All samples were dried at 55°C in a forced draft oven and ground through a 1 mm sieve for analysis. These dried samples were used to determine the composition of the cell wall frac-

[1] Department of Botany and Plant Pathology.

tion of the plant tissue.

The analyses consisted of neutral detergent fiber (NDF) which is the total cell wall, acid detergent fiber (ADF) which is primarily cellulose and lignin and acid detergent lignin (ADL). The non-lignin portion of plant cell walls represents the fibrous carbohydrate (cellulose and hemicellulose) that is available for digestion by rumen microorganisms while lignin is the non-digestible material that interferes with digestion of other portions of the plant.

During the 1971-72 season, samples were taken from 5 genetic lines in the Stillwater plots on four harvest dates and on one date, 10 samples of Triumph 64 were taken from greenhouse plots. These samples were frozen immediately upon harvest by placing in plastic bags and placing the bags in dry ice. The frozen plant tissue samples were then mixed with pulverized dry ice and passed through a pre-cooled Wiley Mill to grind the sample. After allowing the dry ice to dissipate in the freezer, the ground fresh-frozen samples were analyzed for dry matter, soluble carbohydrates, true protein-nitrogen and non-protein nitrogen by methods which will not be detailed in this report.

Results and Discussion

The results from analysis for cell wall constituents are presented in Table 1. NDF was higher for the samples harvested in January and March while ADF did not increase until March. These fractions would be expected to increase as soon as the wheat plants started their spring growth. In the two sets of samples harvested at Stillwater, the lignin (ADL) values were only about 3 percent. This together with the other analyses would suggest that the cell wall portion of the wheat plant tissue would be highly digestible. However, no digestibility measurements have been made as yet.

Table 1. Cell Wall Analysis of Wheat Pasture Samples Harvested In 1970 and 1971.

Harvest date	Location	No. Spls.[1]	NDF[2]	AF-NDF[2]	ADF[2]	ADL[2]
				%, moisture free basis		
10-30-70	Goodwell	10	34.8	31.2	18.2	–
12-12-70	Goodwell	10	28.7	24.9	16.0	–
1-29-71	Goodwell	10	44.2	39.7	17.2	–
1-30-71	Goodwell	10	44.4	41.5	22.5	–
10-15-71	Stillwater	10	–	–	24.0	3.13
11-19-71	Stillwater	10	–	–	22.5	2.89

[1] The 10 samples represented 5 genetic lines. There were no differences between genetic lines.
[2] NDF=neutral detergent fiber; AF-NDF=ash free NDF; ADF=acid detergent fiber and ADL=acid detergent lignin.

Table 2 presents the results from analysis for soluble carbohydrates and nitrogen fractions. In contrast to the cell wall constituents, soluble carbohydrates are generally fermented very rapidly by the rumen microorganisms and are usually 100 percent digestible. They are made up of simple sugars and soluble starch fractions. Ordinarily, significant quantities of soluble carbohydrates occur only in the vegetative stage of plant growth or in plants having high potential for seed formation (e.g., the corn plant). Dried winter forages contain practically none. As can be seen in Table 2, the soluble carbohydrate content of wheat pasture plants varied from 9 to 25 percent of the dry matter. Such a high level of soluble carbohydrate would certainly partially account for the high energy value of this material and its ability to support rapid animal gains.

Table 2. Dry Matter, Soluble Carbohydrate and Nitrogen Fractions in Wheat Pasture Samples Harvested in the 1971-72 Season.

Harvest Date	No. Spls.	Dry Matter	Soluble Carbohydrates	Nitrogen: Crude Protein	% of N as: NPN	% of N as: True Protein
		%	%, moisture free basis		%	%
10-19-71	10[1]	13.7	10.3	27.9	13.1	86.9
11-30-71	10[1] (6)[2]	20.2	25.1	25.2	11.6	88.4
1-25-72	10[1]	22.2	18.2	31.7	27.5	72.5
3- 2-72	3[3]	23.3	–	30.9	15.1	84.9
	10[4]	14.5	9.3	–	–	–

[1] Averages of 10 samples which included 5 genetic lines.
[2] Sufficient quantity for nitrogen fractionation was available for only 6 samples.
[3] Sufficient quantity was available for only 3 samples.
[4] 10 samples of Trumph 64 from greenhouse tests.

The crude protein content was high at all times, varying from 25 to 32 percent of dry matter. This is far in excess of any requirement the animals might have. There are apparently still some cattlemen providing protein supplement to animals on wheat pasture and these results would indicate that this is an unnecessary practice. Furthermore, of the nitrogen present, as much as 27 percent was present as non-protein nitrogen. Although the rumen microorganisms have the capacity for utilizing NPN, the presence of this much in companion with high protein levels suggests that rapid liberation of ammonia from these materials could conceivably cause ammonia toxicity. This possibility is under further investigation at this time.

The Production of Multiple Births In Beef Cows By Gonadotropic Hormone Injection Timed From a Synchronized Estrus

M. R. Johnson, E. J. Turman, J. G. MaGee, D. F. Stephens and J. E. Cothren

Story in Brief

Four groups of lactating beef cows were given subcutaneous injections of 1080 IU of PMS on day-5 and 1440 IU of PMS on day-17 of the estrual cycle, with the injections timed from either a non-synchronized estrus (treatment I) or an estrus synchronized by the individual feeding of an oral progestogen, CAP, for 18 days (treatments II, III, IV). At the first estrus following the second PMS injection the cows were either bred by natural service (treatments I and II) or by artificial insemination (treatment III) and given an intravenous injection of 2500 IU of HCG. In treatment IV the cows were given the intravenous injection of 2500 IU HCG on the third day following the second PMS and were artificially inseminated at that time and 24 hours later regardless of the occurrence of estrus.

Of the 65 cows treated, 21 (32.3 percent) conceived at the first estrus following the second PMS injection and produced 9 singles and 12 multiple (7 sets of twins, 4 sets of triplets and 1 set of quadruplets). Of the cows not conceiving at the first post-PMS estrus, 33 conceived at a later estrus for an overall conception rate of 83.1 percent.

Conception rate at the first post-PMS estrus was higher in treatment I (66.7 percent) than in the estrus synchronized groups (31.3, 18.8 and 16.7 percent for treatments, II, III and IV, respectively). However, each of the latter three treatment groups produced at least two sets of multiples.

Liveability was better for the single born calves (89 percent) than for twins (78.6 percent), triplets (75.0 percent) or quadruplets (50.0 percent). Single born calves reared as singles were heavier at weaning than were multiple born calves reared as twins. Weaning weights were: singles, 497 lbs.; twins, 380 lbs.; triplets, 382 lbs.; and quadruplets 348 lbs.

Despite the low conception rate in the synchronized groups and reduced survival of multiple birth calves, calving rate was markedly influenced by multiple births in this study. A total of 61 calves were

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In cooperation with USDA, Agricultural Research Service, Southern Region. Appreciation is expressed to Dr. J. F. Wagner, Eli Lilly Co., Greenfield Laboratories, Greenfield, Indiana for providing the PMS, HCG and CAP used in this study.

weaned resulting in a calving rate of 142.9 percent based on the 21 cows conceiving at the first post-PMS estrus, 113.0 percent based on the 54 pregnant cows wintered, or 93.8 percent based on the 65 cows originally treated.

Introduction

The major portion of the commercial cattleman's overhead expenses is the result of the combination of high maintenance costs and relatively low productivity of the beef cow. Not only is she, at best, limited to one saleable commodity or product per year, namely her calf, but 10-20 percent of the cows in the herd do not even produce a calf. Combine this with the long gestation period of those that do produce and it becomes apparent that the beef cow is one of the most inefficient of our farm animals.

The vital importance of increasing the productivity of beef cow herds has stimulated considerable research. One very promising field of such research has been in the area of seeking to increase the occurrence of multiple births. Previous work at Oklahoma State University has clearly demonstrated that one way in which the incidence of multiple births in beef cattle can be greatly increased is by the injections of the gonadotropic hormone preparations pregnant mare serum (PMS) and human chorionic gonadotropin (HCG). In these studies the hormone injections were timed from day of estrus in each cow and were followed by natural service.

Therefore, although successful, one big limitation to the use of these treatments in practical production is the large labor requirements to detect heat and to give the injections on an individual cow basis. Other studies at OSU have shown that multiple births could be produced if these hormone injections were given at a synchronized estrus. Thus, a considerable reduction in labor requirements should be obtained if a large portion of the cow herd would come in heat on some predictable day so there would be no necessity to check for the occurrence of estrus and all could be given their injections on the same day.

This paper presents the results of a study based on the most promising of the previous studies and was designed to test a practical procedure for inducing multiple births in which the injections of gonadotropic hormones were combined with estrus synchronization and artificial insemination.

Methods and Materials

This study was conducted at the Fort Reno Research Station from May, 1970 to October, 1971, using a herd of 65 lactating cows of mixed ages consisting of straightbred Herefords and Hereford X Angus or Angus X Holstein crossbreds. The cows had calved in February, March and April and were assigned to one of four different treatment groups on the basis of breeding and age of cows, and age and sex of calf. No cow was started on treatment earlier than 50 days after calving in an attempt to obtain maximum response to the oral progestogen used in estrus synchronization.

The treatments used in this study are described in Table 1. All cows received two injections of PMS[1] subcutaneously in the neck region, 1080 IU given early in the cycle (first PMS) and 1440 IU given late in the cycle (second PMS). AH HCG[2] injections were at a level of 2500 IU given intravenously. The individual doses of PMS and HCG were suspended in 10 ml. distilled water or saline, respectively, just prior to time of injection.

Treatment Group I was considered to be the control group for this study since it was a repeat of the most successful treatment used in past studies at Fort Reno. The cows were not estrus synchronized and were given their first PMS injection on day-5 and their second PMS on day-17 of the estrus cycle timed from the previous estrus of each cow with the day of that estrus counted as day-0 of the cycle. On the day of estrus following the second PMS injection each cow was bred by natural service and injected with HCG.

In the three remaining groups of cows, estrus was synchronized by feeding an oral progestogen, 6-chloro-$\triangle^{6}$-17 acetoxyprogesterone (CAP)[3],

[1] Lyophilized powder containing 72 IU PMS/mg. supplied by Eli Lilly Company, Greenfield Laboratories, Greenfield, Indiana.
[2] Lyophilized powder containing 80 IU HCG/mg. supplied by Eli Lilly Company, Greenfield Laboratories, Greenfield, Indiana.

Table 1. Schedule of Treatments.

Treatment Group	No. Cows	Synchronized (CAP)[1]	Day of PMS Injections[2] (Post-Estrus or Post-CAP) 1080 I.U.	1440 I.U.	Day of HCG[2] (2500 I.U.) and Breeding	Type of Breeding
I	15	No	Day-5[3]	Day-17[3]	Day of Estrus	Natural
II	16	Yes	Day-8[4]	Day-20[4]	Day of Estrus	Natural
III	16	Yes	Day-8[4]	Day-20[4]	Day of Estrus	A.I.
IV	18	Yes	Day-8[4]	Day-20[4]	Day-3 Post-PMS	A.I.

[1] 10 mg./head/day for 16 days then 5 mg./head/day for 2 days.
[2] PMS injections subcutaneous, HCG injections intravenous.
[3] Post-Estrus, with day of estrus counted as day-0.
[4] Post-CAP, with last day of CAP feeding counted as day-0.
[5] El Lilly Company, Greenfield Laboratories, Greenfield, Indiana.

for 18 days at a level of 10 mg./cow/day for 16 days followed by 5 mg./cow/day for 2 days. All cows were started on individual feeding of CAP at the same time with no regard for the stage of the estrual cycle of the cow. Previous work had indicated that most cows would be expected to be in estrus on days-2, -3, or -4 following the last feeding of CAP. Therefore, day-3 was designated as the average day of estrus in all cows and was counted as day-0 of the synchronized cycle for the purpose of timing the two PMS injections. All cows received their first PMS injection on day-8 and their second PMS on day-20 following the last day on which CAP was fed. If counted from the average day of estrus of the synchronized cycles these injections were given on days -5 and 17.

Following the second PMS injections the further treatments scheduled for cows of Groups II and III were imposed on day of estrus. At this time the cows of both groups were injected with HCG and the cows of Group II bred by natural service and the cows of Group III by artificial insemination.

Following the second PMS injections the additional treatments scheduled for Group IV were imposed at a set time with no regard to the occurrence of estrus. On the third day post-PMS all cows were injected with HCG followed by artificial insemination of all cows at that time and 24 hours later.

Detection of estrus in all groups was facilitated by the use of sterilized bulls. All artificial inseminations were made with frozen Angus bull semen obtained from a commercial bull stud. Angus bulls of proven fertility were used for natural service at the first post-PMS estrus. Following the post-PMS mating all cows ran in a pasture with Hereford bulls until September 1, resulting in a total breeding season of 60 to 90 days.

The pregnant cows were wintered on native grass pastures at Fort Reno. During approximately the last three months of gestation, or from January to calving, the cattle were supplemented at the rate of about 2.5 lbs. of 21 percent alfalfa-cottonseed meal pellets and 20 lbs. of alfalfa and bermuda grass hay per head per day in an effort to insure that cows pregnant with multiples received ample feed.

With the exception of one cow who was permitted to raise her own triplets, no cows reared more than twins. An effort was made to insure that as many as possible of the cows that calved multiple births reared twins by grafting calves from triplet sets to cows losing all but one calf of their set of multiples. Cows rearing twins ran in a different pasture than did cows rearing singles. No creep feed was provided for any of the calves.

Results and Discussion

Table 2 presents the breeding and calving performance of the cows in this study. Of the 65 cows treated, 21 (32.3 percent) conceived at the first post-PMS estrus, 33 (50.8 percent) conceived at a later heat period, and 11 (16.9 percent) were still open at the end of the 60-90 day breeding season. Fifty-two of the 54 pregnant cows that were wintered calved. With the exception of one cow in Group I, all cows that conceived at the first post-PMS estrus subsequently calved. Since this is the only group of cows that would be expected to have been stimulated by the PMS to produce multiple births, they are the only group of cows for which calving results are listed in Table 2. Twelve of the 20 cows calving in this group, or 60 percent, produced a multiple birth.

Although no untreated controls were included in this study to permit a comparison, the multiple birth rate of 18.5 percent of the total cows treated is well above the 0.55 percent which is commonly reported as the twinning rate for beef cow herds in the United States. The fact that the multiple births listed in Table 2 were predominately twins and triplets, with only one set of quadruplets, suggests that the lower dosage level of PMS used in this study may be more desirable from a practical standpoint than that used in the previous work at Fort Reno. Earlier studies had used levels of 1500 IU and 2000 IU for the first and second PMS injections. The results obtained in Groups II, and III and IV demonstrate that PMS injections can be effectively timed from a synchronized estrus. The results obtained in Group IV, although too limited to be practical, are very encouraging. If additional research can determine dose levels and schedules for injections and inseminations that will improve the level of response, the practical implications of eliminating completely the need for heat detection should be obvious.

Table 2. Summary of the Breeding Performance of All Cows Treated and the Calving Performance of Cows Conceiving at First Post-PMS Estrus.

Treatment Group	Total Cows	No. Cows Conceiving 1st Post-PMS Estrus	No. Open[1]	No. Cows that Conceived at 1st Post-PMS Estrus Producing			
				Singles	Twins	Trips.	Quads.
I	15	10	0	5	2	1	1
II	16	5	2	1	3	1	0
III	16	3	5	1	1	1	0
IV	18	3	4	1	1	1	0
Totals	65	21	11	8	7	4	1

[1] Following 60-90 day breeding season.

The results obtained in Group I are very similar to those obtained in previous years with the same treatment. As shown in Table 2, 66.7 percent of the cows conceived at the first post-PMS estrus, with 40.0 percent of these cows producing multiple births. When compared to the three estrus synchronized groups, cows of Treatment I were superior in conception rate both at the first post-PMS estrus and over the entire breeding season. However, a higher percentage of the cows conceiving at the first post-PMS estrus in the estrus synchronized groups produced multiples (72.7 percent vs 40.0 percent).

The reduced conception rate at the time first post-PMS estrus in Groups II (31.3 percent), III (18.8 percent), and IV (16.7 percent) probably reflect an effect due to the progestogen used for estrus synchronization. Most estrus synchronization studies with beef cows have reported reduced fertility at the synchronized estrus but not at the second or later post-synchronization heat periods. The cows in this study were not bred at the synchronized estrus but rather at the second estrus after synchronization. The results, therefore, suggest that the combination of PMS and progestogens may adversely affect fertility more than does either alone. It will require additional study to learn whether this is the case. There is also the suggestion that artificial insemination technique had a further adverse effect on fertility in Groups III and IV.

The incidence of open cows in Groups II (12.5 percent), III (31.2 percent), and IV (22.2 percent) may also have been influenced by the progestogen used for estrus synchronization and/or by artificial insemination technique. However, it is possible that the large number of open cows was the result of a reduced number of cows conceiving early in the breeding season with the result that most of the cows in these groups were being bred during the more unfavorable part of the breeding season (July and August) when temperatures were high. The detrimental effect of high ambient temperatures on fertility is well known. Again, however, additional study is necessary to determine how the treatments imposed in Groups II, III and IV affected numbers of open cows.

The calving performance of the cows conceiving at the first post-PMS estrus is presented in Table 3. Poor survival rates have proven to be a problem with multiple births, primarily because of losses associated with triplet and larger litters. In this study survival rates were 100 percent for single, 78.6 percent for twins, 75.0 percent for triplets and 50.0 percent for quadruplets. If calves from all cows that calved, regardless of time of conception, are considered, the survival rate for singles was 89 percent. Most losses occurred at time of calving and none later than 4 days after calving. The death loss charged against twins included one set aborted at about 7 months of pregnancy. If survival of twins is restricted to those carried full term the rate becomes 91.7 percent which is

Table 3. The Calving Performance of the Cows that Conceived At the First Post-PMS Estrus.

Item	Type of Birth			
	Singles	Twins	Trips.	Quads.
No. Sets	8	7[1]	4	1
Live Calves	8	11	9	2
Birth Wt. (lbs.)				
Males	85.0	60.2	56.2	33.1
Females	73.6	62.6	48.5	32.0
Gestation (days)	283.6	281.7	271.0	272.0
Retained Placentas (%)	0	50.0	75.0	0

[1] One set aborted — data on 6 sets only.

comparable to that obtained in previous studies. The results reported in Table 3 are similar to those of previous years relative to survival rates of triplets and quadruplets and reemphasizes the desirability of restricting multiple sets to twins.

As shown in Table 3 shorter gestations were associated with multiple births, especially for triplets and quadruplets. Also, as might be expected, single birth calves were heavier at birth than were multiple birth calves. Within multiple birth sets, twins were heavier than triplets and both twins and triplets were heavier than quadruplets.

Multiple births, whether natural or induced by hormone treatments, have always been associated with a higher incidence of retained placentas. This was the case in this study where 6 (54.5 percent) of the 11 cows producing multiple births had retained placentas compared to none of the cows producing single births (Table 3). There was also a trend for a greater incidence of retained placentas in heavier litters rather than in those litters of larger numbers.

Table 4 presents the performance of calves from calving until weaning. All calves surviving the first 4 days of life were alive at time of weaning in the fall. As might be predicted, weaning weights were lighter for multiple born-twin reared calves than for single born-single reared calves. However, when expressed as total pounds of calf per cow, all multiple births resulted in more total pounds of calf weaned per cow even after adjusting for the higher death loss of multiples. This supports the results of previous years.

One of the possible problem areas associated with multiple births is the possibility that cows producing and rearing multiples may either be delayed in rebreeding or fail to rebreed. In this study 54.5 percent of the cows producing and rearing multiples failed to rebreed following calving in 1971 compared to 15.4 percent of the cows producing and rearing singles. These high figures are probably the result of using a

Table 4. Pre-weaning Performance of Calves Produced by Cows Conceiving at the First Post-PMS Estrus.

Item	Type of Birth			
	Singles	Twins	Trips.	Quads.
Total Sets	8	7	4	1
Live Calves	8	11	9	2
Calves Weaned	8	11	9	2
Adj. 205 Day Wt. (Lb.)	496	380	382	348
Lb. Calf per Cow	496	736	860	697

short breeding season of 60-70 days in an effort to move the average date of calving earlier in 1972. It is likely that more of the cows would have settled had the season been of a normal length. However, it is obvious that the cows producing and rearing multiples would have been delayed in rebreeding compared to the cows rearing singles. The factors associated with rebreeding following multiple births is an important area needing further research.

Despite the low conception rate of cows in Groups II, III and IV calving rate was markedly affected by multiple births in this study. A total of 61 live calves were obtained resulting in a calving rate of 142.9 percent for the 21 cows conceiving at the first estrus after PMS, 113.0 percent for the 54 cows wintered, or 93.8 percent for the total group of 65 cows treated. As a result of the treatments used in Group I, an additional weaner calf was obtained for every three cows treated.

There can be no doubt that the hormonal induction of multiple births has great potential for increasing the productivity of beef cow herds. However, there still remains a number of important questions that need to be answered by additional research before it can be recommended for use in commercial production.

Pre-Weaning Growth Of Large And Small Scale Beef Calves

J. D. Gresham, J. J. Guenther, J. R. Escoubas
L. E. Evans[1], R. D. Morrison[2] and A. A. Rutledge

Story in Brief

Pre-weaning rate of growth and maturity of eight small scale (Angus) and eight large scale (Charolais) calves was studied. Data utilized for evaluating rate of growth was obtained from skeletal linear measurements and radiographs of the left metacarpal.

Results indicated a significant ($P<.01$) difference in the growth rate of these two groups of calves with the small scale group (Angus) being smaller. Metacarpal radiogram data indicated that the small scale calves reached physiological maturity during the pre-weaning phase of their lifetime. However, these data suggest that physiological maturity in the large scale calves is not attained until the post-weaning life phase. The difference in the time at which physiological maturity is attained could have important economical considerations. It would appear that whereas the large scale calves are normally placed in a dry lot at the same age as the small scale calves, they are still immature in skeletal development. Also, the smaller scale beef breeds may well be suited for placing in a feedlot earlier than is the current practice from an economical standpoint.

Introduction

For many years, a primary goal of animal scientists has been to selectively breed and produce meat animals with the ability to grow rapidly and deposit large percentages of "quality" lean tissue as efficiently as possible. Much effort has been expended in the measurement and evaluation of gross indices such as weaning weight, average daily gain, ribeye area, etc. These estimators of genetic breeding potential have certainly contributed to the improvement of the livestock industry. Consequently, considerable research effort has been directed to the performance of the live animal after weaning with little study of the life span from birth to weaning. With the recent introduction of the fast growing "exotic" breeds, questions have arisen as to the validity of these measurements when applied to breeds of different growth rates and rates of maturity.

[1] Department of Radiology, College of Veterinary Medicine
[2] Department of Statistics, College of Arts and Sciences

The purpose of this study was to determine certain physiological changes relating to the growth and development of an "early" or "fast" maturing, small scale bovine breed and a "later" or "slower" maturing, large scale breed from immediately after birth to weaning.

Materials and Methods

The experimental animals for this study were eight grade Angus steer calves and eight Charolais cross (7/8 Charolais x 1/8 Angus) steer calves. Skeletal measurements were obtained at four stages of growth from birth to weaning. Skeletal measurements were: 1) body depth, measured from topline to sternum parallel to the 5th rib; 2) thickness of forequarter, measured between the lateral surfaces of the shoulders; 3) thickness of hindquarter, measured between the lateral surfaces of the round; 4) thickness of rump, measured between the lateral surfaces of the tuber coxae; 5) length of rump, measured by the distance from the anterior surface of the tuber coxae to the posterior surface of the tuber ischii; 6) depth of forequarter, measured from the proximal surface of the cartilage of the scapula to the olecranon; 7) body length, measured along the topline of the animal from the proximal anterior point of the scapula to the posterior surface of the tuber ischii; and 8) length of side measured from the anterior surface of the lateral tuberosity of the humerus to the anterior point of the tuber coxae.

All skeletal measurements were accomplished in duplicate. Live weight at each evaluation period was also obtained on each animal. In addition, the left metacarpal of each animal was radiographed at the OSU Veterinary Medicine Radiology Laboratory in order to evaluate bone development and maturity.

The Angus calves averaged 41 days of age and the Charolais calves 32 days of age at the first evaluation period. Periods 2, 3, and 4 were subsequent evaluation periods of 56 day intervals for both groups.

Results and Discussion

The analysis of the data presented in this study is derived from values obtained at a specific period in the lifetime of the individual. However, in analyzing any growth pattern one must keep in mind that the pattern of growth is not composed of point-to-point changes, but is a continued balance of gain and loss of total animal mass. This pattern is normally linear during the earlier, more rapid phase of growth followed by a curvilinear pattern as maturity is approached. A change from a linear to a curvilinear growth curve may then be used to estimate differing rates of maturity between the breeds of differing rates of maturity.

The statistics of variation utilized in this analysis were breed variation and period variation as the main effects, as well as a breed x period interaction. Table 1 presents the tests of significance utilized for live weight and the eight skeletal measurements. It is apparent that there was no significant ($<.05$) breed difference between the Angus group and the Charolais group from birth to weaning when analyzed for the variable, live weight. There was a significant ($P<.01$) period effect and breed x period interaction for live weight during this span of the calves lifetime.

This difference in growth rate may best be illustrated by Figure 1. The curves in Figure 1 reflect the change in live weight of the two breeds through the first 168 days on this study (pre-weaning phase). As noted, Period 1 represents the initial evaluation of the animals followed by three subsequent evaluations in 56 day increments, referred to as Periods 2, 3 and 4. During the first 56 days on trial (Period 1 to Period 2), the Angus calves increased in live weight from 53.81 kg. to 91.17 kg., a total increase of 37.36 kg. During this same length of time, the Charolais calves in-

Table 1. Mean Values for Linear Measurements and Radiogram Analysis by Period

Variable	Breed	Period 1[1]	2[2]	3[2]	4[2]
Live Weight[4]	A[3]	53.81	91.17	135.91	169.53
	C[3]	52.56	93.84	153.32	211.15
Body Depth[5]	A	30.91	38.26	42.98	46.36
	C	31.50	38.53	45.23	50.41
Thickness of Forequarter[5]	A	25.30	29.05	32.34	34.47
	C	22.61	26.92	31.52	36.20
Thickness of Hindquarter[5]	A	27.42	32.42	36.39	39.17
	C	27.05	32.55	39.26	43.62
Thickness of Rump[5]	A	18.38	22.94	27.15	30.13
	C	18.41	23.04	31.88	32.27
Length of Rump[5]	A	23.25	27.73	31.35	33.81
	C	24.67	29.61	34.27	41.87
Length of Topline[5]	A	60.36	76.31	86.92	95.54
	C	63.99	78.71	89.21	99.47
Length of Side[5]	A	47.20	56.32	66.01	72.14
	C	50.66	60.28	69.79	79.40
Depth of Forequarter[5]	A	27.03	31.86	35.76	39.37
	C	29.58	34.12	39.79	43.46
Metacarpal Length[5]	A	14.49	16.28	17.01	17.20
	C	17.02	18.05	19.08	20.22
Metacarpal Area[6]	A	40.20	49.42	57.59	59.02
	C	49.44	55.25	60.97	72.29

[1] Average age of Angus = 41 days; Charolais = 32 days
[2] Increments of 56 days between Periods
[3] A = Angus; C = Charolais
[4] Expressed in kg.
[5] Expressed in cm.
[6] Expressed in $cm.^2$

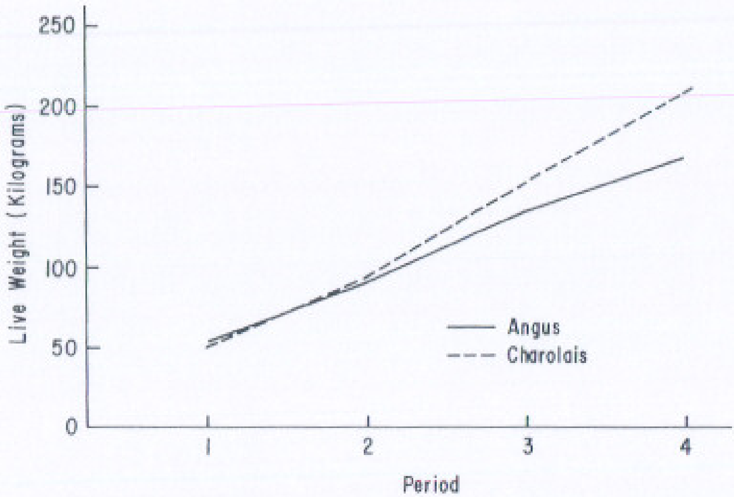

Figure 1. Mean Live Weight by Period

creased in live weight from 52.56 kg. to 93.84 kg. or a gain of 41.28 kg. Thus, the Charolais calves out gained the Angus calves by 3.92 kg. during this time. Between Periods 2 and 3, the Charolais gained a total of 59.48 kg. as compared to 44.74 kg. for the Angus, a plus of 14.74 kg. in favor of the faster growing Charolais. Between Periods 3 and 4, the Charolais out gained the Angus by 24.21 kg. Overall, during the first 168 days, the mean live weight for the Angus and Charolais was 112.61 kg. and 127.72 kg. respectively. This, however was not significant at the 5 percent level of probability.

Obviously, the period variation is significant ($P<.01$). In analyzing the rate of growth of the two groups it may be noted that the Charolais group exceeded the Angus at each period (after Period 1), with each period difference in live weight being successively larger than the previous period (i.e. 3.92 kg., 14.74 kg., and 24.21 kg. for Periods 2, 3 and 4 respectively). This steady increase in live weight in favor of the Charolais created the significant ($P<.01$) breed x period interaction illustrated in Table 2. This interaction indicates that while both breeds are increasing in live weight, the faster growing Charolais are increasing at a more rapid rate than the slower growing Angus.

While live weight may be used as one criteria for studying patterns of growth, it would also be useful to know if there are differences in patterns of growth within the skeletal structure of the animal. The eight skeletal measurements previously mentioned were analyzed using the

Table 2. Tests of Significance for Variable Live Weight

Source	df	Sum of Squares	Mean Square	F Value
Breed	1	35511.13	35511.250	3.94
Animal (Breed)	14	126146.75	9010.482	
Period	3	1675626.63	558542.208	2033.66**
Animal x Period (Breed)	42	11535.25	274.649	
Breed x Period	3	43951.13	14650.375	53.34**
Animal x Breed (Period)	42	11535.25	274.649	

** Significant ($P < .01$)

same statistics of variation as for live weight. Data in Table 3 represent a summary of the significance levels for each variable. The same explanation as to significance of the main effects and the interaction presented above for live weight is applicable to these linear measurements.

Table 1 contains a summary of the mean values for all linear measurements. From this data one may analyze differences in development of the skeletal structure between the two breeds and how and when they may differ. No effort will be made at this time to plot the linear and curvilinear phases of the various growth patterns due to the limited data presently available.

In summarizing the linear measurement data in Tables 1 and 3, it is apparent that there was a significant ($P < .01$) period effect for all variables studied. Also, there was a significant ($P < .01$) breed effect for three variables, length of rump, depth of forequarter, and length of side. The breed x period interaction, previously discussed, was significant ($P < .01$) for all variables except thickness of rump, length of topline, and depth of forequarter. Depth of forequarter was significant at the 5% level of probability, however. It is interesting to note that there was a significant ($P < .01$) breed and period effect for length of rump, but no interaction. Also, the thickness of rump and length of topline showed only a significant period effect. From these data, one would surmize that while there are evident differences in the growth rate between these two breeds from birth to weaning, the basic measures of scale (i.e. width and length) show similar trends of skeletal development.

While body weight and skeletal development provide visible and physical estimators of rate of growth, another index that may be even more precise is X-ray observation of a specific bone. From this type of observation, the actual time at which long bone growth occurs as well as the amount of long bone growth may be determined. For this study, radiogram data were obtained on the left metacarpal of each animal at each period of evaluation in order to estimate physiological maturity, in

Table 3. Summary of Significance Levels of Skeletal Measurements and Radiogram Analysis

Variable	Statistic of Variation		
	Breed	Period	Breed x Period
Live Weight	ns	**	**
Body Depth	ns	**	**
Thickness of Forequarter	ns	**	**
Thickness of Hindquarter	ns	**	**
Thickness of Rump	ns	**	ns
Length of Rump	**	**	ns
Length of Side	**	**	**
Depth of Forequarter	**	**	*
Length of Topline	ns	**	ns
Length of Metacarpal	**	**	**
Area of Metacarpal	**	**	**
Metacarpal Length	**	**	**
Metacarpal Area	**	**	**

ns = Non-Significant ($P > .05$)
* = Significant ($P < .05$)
** = Significant ($P < .01$)

addition to bone growth. The two variables selected for analysis were metacarpal length and metacarpal area. These results are presented in Figures 2 and 3 and Tables 1 and 3. The same statistics of variation dis-

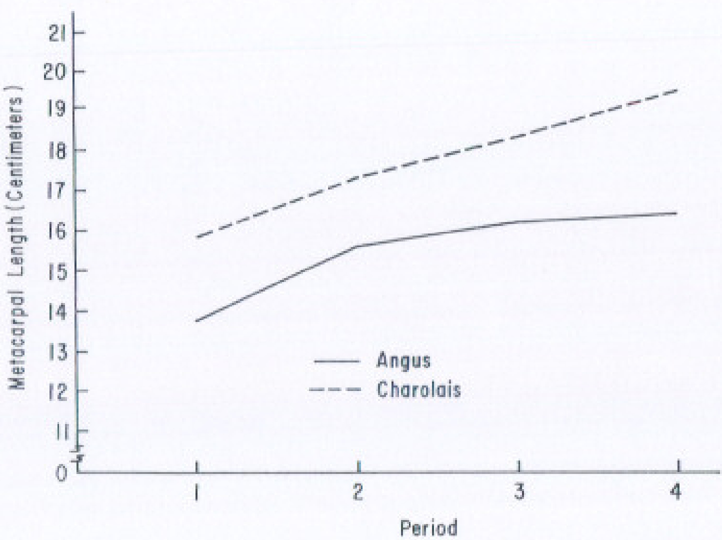

Figure 2. Mean Metacarpal Length by Period

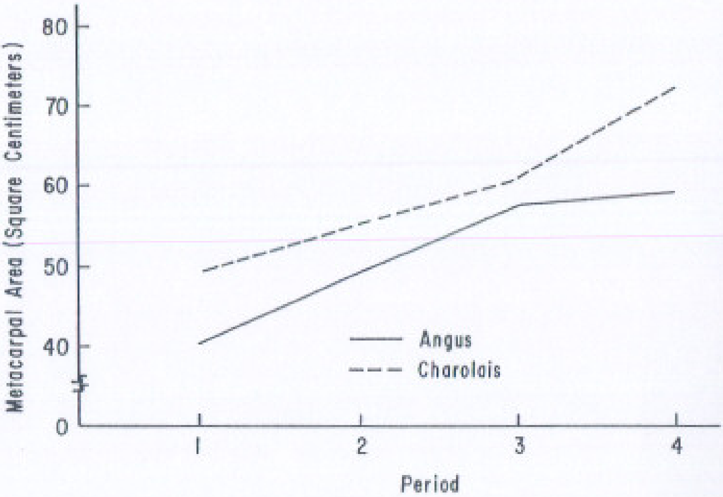

Figure 3. Mean Metacarpal Area by Period

cussed above were utilized for the radiogram data. It is apparent from the data plotted in Figure 2, that the change from a linear growth pattern to a curvilinear pattern has already occurred within the Angus group. This response is not apparent in the Charolais group, which appears to be still linear. Data available indicates that the Angus group has approached physiological maturity, at least for this particular variable. This apparently occurred sometime between 154 and 210 days of age. The results for the Angus calves seem to be in agreement with Guenther *et al.,* (1965) who reported that Hereford beef calves at seven months of age had already reached 87 percent of their final size. However the Charolais calves apparently mature later according to the present results.

Analysis of metacarpal area (Table 1) and rate of growth (Figure 3) reflect a similar pattern of growth through Period 3 with the Angus growing in total bone area at a more rapid rate than the Charolais. A definite leveling response is observed between Periods 3 and 4 along with a converse rapid increase in area for the Charolais. In comparing the slope of the growth curve for the Angus between Periods 2 and 3 for both length and area, it may be seen that while the length slope is decreasing, the area slope is not; therefore this bone appears to be growing in area faster than in length. The slope between Periods 3 and 4 are almost identical. Now, a similar slope is noted in the Charolais group for Periods 1 to 3 for both area and length. However, the area slope is much greater than the length slope between Periods 3 and 4. From this one may postulate that a decline in bone growth might be noted in the early "feedlot" phase of this study.

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Performance Of Three-Year-Old Hereford, Hereford x Holstein And Holstein Females As Influenced By Level Of Winter Supplement Under Range Conditions

J. W. Holloway, D. F. Stephens, Leon Knori, Keith Lusby, Art Dean, J. V. Whiteman and Robert Totusek

Story in Brief

The productivity of winter-calving, 3-year-old Hereford, Hereford x Holstein and Holstein females under tallgrass range condition was compared. Two levels of supplementation (Moderate and High) were imposed on groups within each breed at calving and extended through the rest of the winter. An additional level of supplementation (Very High) was fed to a group of Holstein females.

As level of supplementation increased, winter weight loss decreased except for the Herefords. Cows in each group regained their winter weight loss the following summer except the Moderate Holsteins. Condition scores followed trends similar to winter weight losses and summer gains. Daily milk yield for the Hereford, Hereford x Holstein and Holsteins females was 14.0, 21.7 and 28.8 lb/day, respectively. Birth weights

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

were 85, 86 and 96 lb., respectively; and weaning weights were 597, 645 and 730 lb., respectively.

As level of supplementation increased, cows tended to exhibit estrus and conceive sooner. The moderate Hereford x Holstein female had the greatest dollar return above land and supplement costs per produtive cow, but their poor rebreeding performance as three-year-olds decreased their net efficiency so that the most economical producers of weaned beef were the Herefords.

Introduction

Weaning weight is one of the most important economic factors in beef production. Selection for weaning weight automatically results in selection for milk production because of the high correlation between level of milk production of beef cows and weaning weight of their calves. Milk production potential can be increased most rapidly by infusing genes for high milk production from dairy animals.

The conversion of milk to calf gain is a rather efficient process within the limits of milk production of the beef cow. Within this range, the conversion is approximately 10 lb of milk per pound of gain. This conversion may not be as efficient at high levels of milk production. Although it is possible to increase the level of milk production of range beef cows, the increased feed requirements of the cow 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 in milk production potential.

Methods and Materials

Groups of Hereford, Hereford x Holstein and Holstein females have been continuously maintained under tallgrass native range conditions at the Fort Reno Livestock Research Station since they were one year old. At first calving, they were assigned to a level of winter supplementation on the basis of a pre-assigned calving order to equalize calving date within breed. The Design of the experiment is presented in Table 1.

Within each breed, the females were subjected to two levels of winter supplementation designated as Moderate and High. The Moderate level consisted of that amount of supplemental feed deemed necessary to allow good rebreeding performance in the Hereford females. Previous experience at the Fort Reno Livestock Research Station suggested a winter loss (including weight loss at calving) from fall to spring of 10 percent for yearling heifers bred to calve at 2 years of age and 15 percent for 2-

Table 1. Calving and Weaning Data

Item	Hereford		Hereford x Holstein		Holstein		
	Moderate	High	Moderate	High	Moderate	High	Very High
No. of calves weaned	12	8	9	12	3	8	8
Male	7	7	1	4	1	3	5
Female	5	1	8	8	2	5	3
Avg. calving date[1]	369	373	359	366	363	370	364
Avg. birth wt., lb.	84	85	86	86	100	92	96
Avg. adj. weaning wt., lb.	601	592	645	641	723	736	730

[1] Day of year, January 1, 1971 = 001

year-old females, rebred to calve at 3 years of age. The same level was fed to a group of Hereford x Holstein females and to a group of Holstein females.

The High level was established by the Hereford x Holstein females and consisted of that amount of supplement estimated necessary to maintain a body condition and physiological activity comparable to that of the Moderate Herefords; this same level was fed to a group of Hereford females and to a group of Holstein females. Also, a Very High level was fed to a group of Holstein females. This level was established by the Holstein females and consisted of that amount of supplement estimated necessary to maintain a body condition similar to the Moderate Herefords and High Hereford x Holstein crossbreds; 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 which were fed, as 2-year-olds, an average of 2.6, 5.5 and 7.7 lb./head/day post-calving of a 30 percent crude protein supplement, respectively. As 3-year-olds they were fed 3.1, 6.3 and 9.2 lb./head/day, respectively. Within each nutritional treatment, the quantity of supplement fed each female was adjusted for differences in body sizes. Supplement intake by treatment and breed is summarized in Table 2.

The females were bred as yearlings to Angus bulls; their performance as 2-year-olds was summarized by Kropp et al., 1972. As 2-year-olds they were bred to Charolais bulls; this report summarizes their performance as 3-year-olds. The females were artificially inseminated to one Charolais bull for 23 days, then hand mated for 22 days and pasture exposed for 45 days to three half-sib Charolais bulls.

Table 2. Supplement Intake

Item	Hereford		Hereford x Holstein		Holstein		
	Moderate	High	Moderate	High	Moderate	High	Very High
Supplement, lb.[1]							
Total winter[2]	353	691	343	763	390	780	1189
Avg. daily, winter	2.24	4.40	2.19	4.86	2.49	4.97	7.57
Avg. daily, pre-calving	0.82	1.53	0.84	2.02	0.97	2.24	3.90
Avg. daily, post-calving	3.05	6.09	2.86	6.33	3.30	6.40	9.16

[1] Soybean meal (44%), 60.1%; milo, ground, 30.3%; dehydrated alfalfa meal 5.0%; dicalcium phosphate, 2.9%; Masonex 1.3%; salt, 0.5%; plus vitamin A added at 10,000 IU/lb of supplement.
[2] November 9, 1971 to April 15, 1972.

Monthly individual cow weights (after a 6-hour shrink) were taken from November, 1971 to November, 1972. Cow winter weight losses were calculated from November, 1971 to the lowest weight after calving (March). Cow conditions scores were taken prior to initiation, after termination and before re-initiation of the supplemental feeding period. The scale for condition score was from 1 (very thin) to 9 (very fat).

All calves were weighed within 24 hours after birth and remained with their dams on native pasture until weaning; no creepfeed was fed. During lactation, monthly calf weights (after a six-hour shrink) were adjusted to 240 days by interpolation or extrapolation. The age-corrected weaning weights of the heifer calves were adjusted to a steer equivalent by multiplying by a factor of 1.05.

The 24-hour milk production was estimated by the calf suckle technique. The first estimate was taken when the calves were four to six weeks of age and then monthly until seven estimates had been taken.

Results and Discussion

Cow Weight and Condition

The amount of winter weight loss decreased as level of supplementation increased except for the Herefords (Table 3). The High Herefords lost more weight during winter (28 lb.) than the Moderate Herefords. Apparently the Moderate level provided adequate supplementation for Herefords, and increasing supplementation to the High level resulted in a decrease in forage intake; the High Herefords also produced more milk

[1] Oklahoma Agricultural Experiment Station Miscellaneous Publication 87, pp. 26-36.

Table 3. Weight, Weight Change and Condition Data

Item	Hereford		Hereford x Holstein		Holstein		
	Moderate	High	Moderate	High	Moderate	High	Very High
Weight, lb.							
Fall, 1971 (Pre-calving)	1012	1022	995	1070	1187	1172	1210
Spring, 1972 (Mid-lactation)	850	832	812	897	912	955	1011
Fall, 1972 (Post-lactation)	1035	1046	1011	1092	1168	1172	1240
Weight change, lb.							
Winter	—162	—190	—183	—173	—275	—217	—199
Summer	+185	+214	+199	+200	+256	+217	+229
Year	+ 23	+ 24	+ 16	+ 27	— 19	0	+ 30
Weight change, %							
Winter	—16.00	—18.59	—18.39	—16.17	—23.17	—18.52	—16.45
Summer	+21.76	+25.72	+24.51	+22.30	+28.07	+22.72	+22.65
Year	+ 2.27	+ 2.35	+ 1.61	+ 2.52	— 1.60	0	+ 2.48
Condition score[1]							
Fall, 1971 (Pre-calving)	5.69	6.10	4.27	4.85	3.33	3.00	3.75
Spring, 1972 (Mid-lactation)	4.46	4.40	2.27	3.23	1.33	1.78	2.38
Fall, 1972 (Post-lactation)	6.58	6.40	4.90	4.92	3.00	4.00	4.50

[1] Condition score; very thin = 1, . . . , very fat = 9.

than the Moderate Herefords. Similar to the previous year (when they were 2-year-olds), the 3-year-old Hereford females that lost more weight in the winter gained more weight in the summer. This trend was not as apparent for the Holsteins and Hereford x Holstein females although the Moderate Holsteins gained more than the other Holstein treatments. The Moderate and High Holsteins did not increase in weight during the year as is normally observed between 3 and 4 years of age.

Generally, condition scores followed the trends of winter weight losses and summer weight gains. The High Herefords lost more condition than the Moderate females but they were much fatter than the Moderates in the fall before calving. As 2-year-olds a trend existed for the groups that lost the most condition during the winter to compensate by gaining more in the summer. As 3-year-olds, however, the trend was not as distinct. Moderate Holsteins and Moderate Hereford x Holstein crossbreds lost the most condition in the winter (2.00 units each); the Moderate crossbreds compensated by gaining 2.63 units of condition in the summer but the Moderate Holsteins only gained 1.67 units of condition, probably due to a higher level of milk production.

The cow weights during pre-partum, lactation and post-lactation periods are presented graphically in Figure 1. The loss in weight between the first and second month is primarily due to weight loss at calving. All breed-treatment groups tended to continue to lose weight until the fourth month (third month of lactation) after which a steady increase in weight until weaning was noted. The Holsteins remained heavier throughout the trial than the Herefords and crossbreds. Weight of the two Hereford groups was very similar throughout the year, again indicating that the Moderate level of supplementation was adequate. However, Moderate Hereford x Holstein crossbreds and Holsteins were considerably lighter in weight than their higher supplemented breed mates during the peak months of lactation; the Moderate crossbreds remained lighter to weaning time.

Calf Weight

Birth weights and 240-day sex-corrected weaning weights are presented in Table 1. Calves out of Holstein cows were heavier than those out of Hereford x Holstein cows. Since all females were bred to common Charolais bulls, the differences in birth weight were probably due to the larger body size of the Holstein females. At weaning calves out of Hereford, Hereford x Holstein and Holstein cows weighted 597, 643

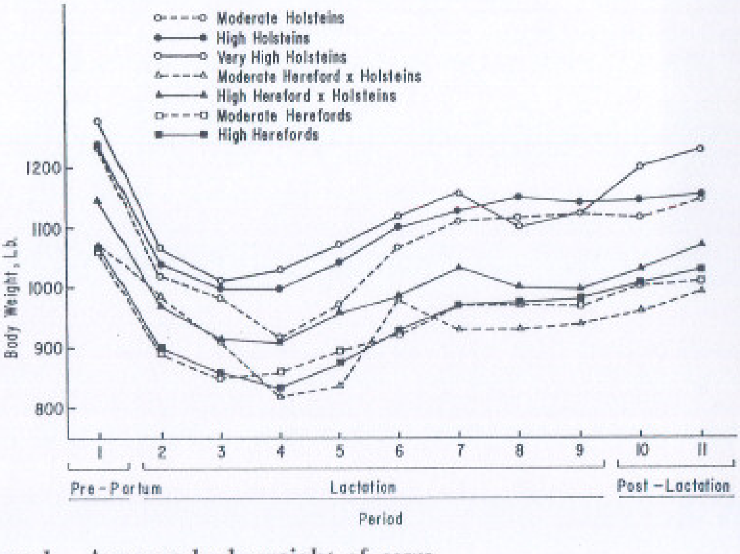

Figure 1. Average body weight of cows.

and 730 lb., respectively. Level of winter supplement within breed had little influence on weaning weight, as was true the previous year.

Milk Yield

The greatest difference in total milk yield was between breeds with the Herefords, Hereford x Holsteins averaging 3348, 5208 and 6920 pounds compared to 2988, 4392 and 5824, respectively, when they were 2-year-olds. Cows on the higher levels of supplementation tended to produce slightly more milk within each breed (Table 4), but this was not reflected in differences in weaning weight. Lactation curves for the three breed groups remained separate (Figure 2) with the previously mentioned trend for the groups receiving higher levels of supplementation to consistently produce more milk.

The lactation curves were remarkably flat and were similar to those of the same females as 2-year-olds, in contrast to earlier reported lactation curves, probably due to the availability of spring grass when milk yield normally declines. The Holsteins actually increased in milk production through the fifth month of lactation, probably because of the increased capacity of the calf at the time of lush grass in the spring during periods 4 and 5 (March and April). Spring grass seemed to increase milk production for the females fed lower levels of winter supplement relatively more than that of females on higher levels.

Reproductive Performance

A definite trend existed for the number of days to first observed estrus and the number of days to apparent conception to decrease as level of winter supplementation increased, especially in the Holsteins (Table 5). More cows were used to calculate reproductive performance (Table 5) than weaning data (Table 1) because some cows whose calves had died raised a foster calf. Their reproductive data was valid but their calving and weaning data was not. As 2-year-olds, all Herefords, Hereford x Holstein and Very High Holstein females rebred. A possible accumulative effect on reproduction occurred for the Moderate crossbreds since

See Corrected Table p. 285

Table 4. Milk Production Data

	Hereford		Hereford x Holstein		Holstein		
Item	Moderate	High	Moderate	High	Moderate	High	Very High
Total lactation yield, lb.	3120	3576	5040	5376	6552	6912	7296
Daily yield, lb.	13.0	14.9	21.0	22.4	27.3	28.8	30.4

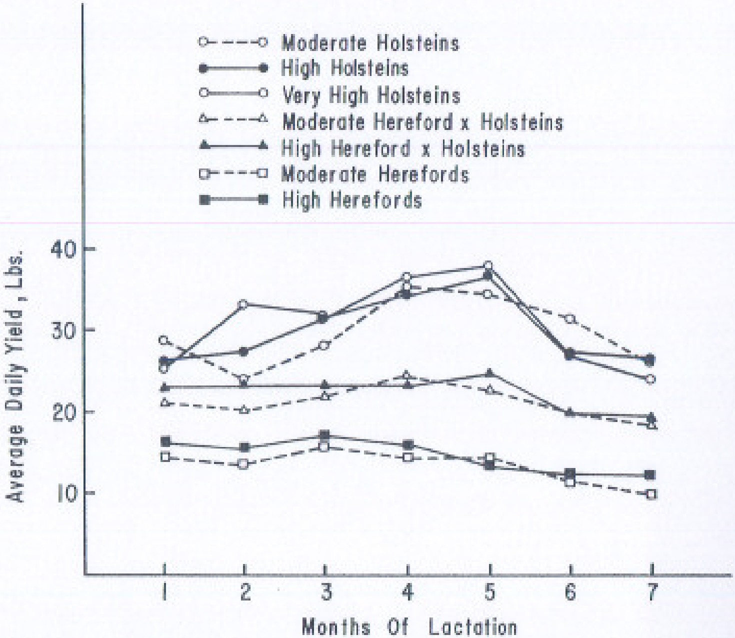

Figure 2. Average daily milk yield.

only 8 of 11 rebred as 3-year-olds. Only one Holstein (a High level female) was open, but it is difficult to appraise the reproductive performance of the Holsteins because of the disproportionate number of females which raised calves as 2-year-olds. This disproportionality was due to the poor reproductive performance the previous year (as 2-year-olds), especially for the Moderate Holsteins. The High Hereford female that was open was probably due to chance; this was the only open Hereford in two productive years.

Economic Analysis

The economic analysis shown in Table 6 is based on Oklahoma 1972 prices. Different prices can be substituted as appropriate.

The assumptions for the economic analysis presented in Table 6 will be described. Cost of the native range was estimated to be $65.00 per year per female for the Moderate Herefords. A drylot trial involving the same breed-treatment groups as this experiment was conducted concurrently. Individual roughage intakes were determined in the drylot trial and served as the basis for estimation of forage consumption of the

Table 5. Reproductive Performance Data

Item	Hereford		Hereford x Holstein		Holstein		
	Moderate	High	Moderate	High	Moderate	High	Very High
No. of females	12	10	11	13	4	9	8
No. of females exhibiting estrus	12	10	9	13	4	8	8
Days post-partum to first observed estrus[1]	72.7	68.3	79.3	66.2	126.7	78.5	57.7
No. of females bred	12	9	8	12	4	8	8
Days post-partum to apparent conception[2]	94.0	90.4	94.0	89.8	140.0	93.9	85.1

[1] Based on those females which exhibited estrus.
[2] Based on those females that conceived.

Table 6. Economic Analysis

Item	Hereford		Hereford x Holstein		Holstein		
	Moderate	High	Moderate	High	Moderate	High	Very High
Land requirement, %[1]	100	92	104	107	131	126	128
Land cost per female, $	65.00	59.65	67.69	69.54	84.87	82.02	83.17
Supplement cost per female, $	15.93	31.14	15.48	34.38	17.55	35.10	53.55
Total land and supplement cost, $	80.93	90.75	83.17	103.92	102.42	117.12	136.72
Average value of calf	243.57	239.64	248.89	247.98	253.27	256.02	254.77
Return above land and supplement cost, $	162.64	148.89	165.72	144.06	150.85	138.90	118.05
Return adjusted for conception, $[2]	162.64	148.89	140.86	144.06	102.58	120.84	110.97

[1] Expressed as % of Moderate Herefords as determined by forage intake in drylot trial.
[2] Based on conception rate as 2-year-olds.

range cows. The percent of forage consumed by each breed-treatment group in drylot compared to that of the Moderate Herefords was multiplied by $65.00 to estimate the land cost of each group. The cost of the supplement was estimated at $90.00.

The calves from the Hereford, Hereford X Holstein and Holstein females was estimated to be worth $43.00, $42.00 and $40.00/cwt for steers and $38.00, $37.00 and $35.00/cwt for heifers, respectively, with a discount of $2.00/cwt for weights above 600 pounds. Estimated calf value was calculated by multiplying the 240-day weaning weight of the steer and heifer calves by their respective price/cwt and then calculating an unweighted steer-heifer average.

On the basis of those cows which weaned calves, the Moderate cross bred females returned the most profit above land and supplement costs ($166.89) followed closely by the Moderate Herefords ($162.73). Looking a year ahead, however, the Moderate Herefords will have an advantage because of better rebreeding performance. (Table 5.) Feeding the High level of supplementation to the Herefords and the Hereford x Holsteins decreased profits by $13.79 and $20.94, respectively. The Holsteins returned less profit than the comparable supplement groups in the other breeds, due to a higher feed requirement.

A more realistic financial return figure would be provided by adjusting for rebreeding performance. This was done by multiplying the return above feed cost per calf by the percent conception of the cows as 2-year-olds (Table 6). On this basis, Moderate Herefords were the most profitable.

Conclusion

Based on performance under range conditions through 3 years of age, Herefords have been most profitable. The additional feed necessary for good rebreeding performance of heavier milking cows weaning heavier calves (Hereford x Holstein crossbreds and Holsteins) has reduced profit.

Value Of Range Cow Supplements Containing Urea, Biuret and Kedlor and Effects Of Methionine-Hydroxy-Analogue And High Levels Of Dehydrated Alfalfa In Urea And Biuret Supplements

Ivan Rush, W. E. Sharp, Ray Helderman and Robert Totusek

Story in Brief

Two groups of cows wintered on dry range grass were individually fed winter supplements to evaluate the supplemental value of non-protein-nitrogen (NPN) from Kedlor, biruet and urea. Two supplements containing 15 and 30 percent natural protein served as negative and positive controls.

The other supplements were formulated to contain 30 percent crude protein equivalent with the NPN (Kedlor, biuret or urea) contributing one-half of the crude protein equivalent. The effects of methionine-hydroxy-analogue (MHA) and high levels of dehydrated alfalfa (40 percent of supplement) when added to supplements containing urea and biuret were also determined.

No consistent pattern was apparent in winter weight loss of cows to indicate a considerable utilization of NPN from Kedlor, biuret or urea. In one group, weight loss of cows on NPN supplements was generally intermediate between that observed for negative and positive controls. In the other group, weight loss observed on NPN supplements was similar to that of the negative control.

The addition of MHA to urea or biuret did not improve the performance of the cows. The MHA decreased the palatability of both supplements, and especially with urea where intake was markedly decreased.

The addition of high levels of dehyrated alfalfa meal did not greatly decrease winter weight loss of cows fed urea and biruet supplements.

Calf gains and weaning weights did not appear to be affected by the winter treatments imposed on the cows.

Appreciation is expressed to Dow Chemical Company, Midland, Michigan, for supplying Kedlor and partial support, NIPAC Chemical Company, Prior, Oklahoma, for supplying the pure biuret and to Dupont Chemical Company for supplying MHA and partial support.

Introduction

Increases in the cost of the plant proteins have caused a considerable increase in the costs of supplemental feed which is the major expense in a cow-calf operation. Due to the increase in the cost of natural protein, interest in and use of urea and other NPN sources continue to increase. Urea has been used extensively in feedlot rations to lower the protein feed costs, and when urea is fed with concentrates it can be effectively used by the rumen micro-organisms to synthesize microbial protein.

Results have also been somewhat promising when urea is used with wintering rations that contain a considerable amount of hay or silage. To date, however, research has shown that utilization of urea by range beef cows grazing low quality dried winter grass is disappointingly poor. Some of the reasons for poor performance when urea is fed are: (1) It is converted to ammonia in the rumen more rapidly than the ammonia can be utilized by the rumen microbial population and is consequently lost. (2) Dry weathered grass is low in readily available energy (soluble carbohydrates) which is needed for the conversion of ammonia to microbial protein. (3) High levels of urea can result in toxicity problems.

The use of NPN can lower the cost of range supplements. In view of the increasing human demand for natural plant proteins, their price will undoubtedly increase in the future. Since the ruminant is unique in being able to convert NPN into edible protein, methods of utilizing relatively high levels of urea and other NPN products must be developed.

Considerable research effort is being exerted to alleviate the disadvantages of feeding urea and to develop other desirable NPN sources. One which appears to be the most promising is biuret, a product of joining two molecules of urea. Biuret has the reported advantage of being broken down in the rumen at a slower rate which should result in a more effective utilization by the rumen microorganisms. Because of the slower release of ammonia there does not appear to be a problem with toxicity.

One disadvantage of biuret is that a period of time is necessary for the rumen microorganisms to become adapted to biuret so that it can be broken down to ammonia. The length of time needed for adaption varies with the level of energy supplied plus other possible factors, but in high roughage rations it may be as much as 30 days. Another current but perhaps temporary disadvantage of biuret is that it is more expensive than urea. A commercially available source of biuret is Kedlor[1].

[1] Kdlor, a product of Dow Chemical Company, Midland, Michigan, contains approximately 60% biuret, 15% urea and 21% cyanuric acid and triuret.

In earlier research, a low level (5 percent of the supplement) ot alfalfa has increased the utilization of urea and biuret. More recent reports suggest that relatively high levels of alfalfa or dehydrated alfalfa (40 percent or more of the supplement) may further enhance the utilization of NPN and also reduce the time required for adaption to biuret.

Limited research has indicated that when cattle are under stress, especially in the case of high producing dairy cows, methionine (an essential amino acid) may be deficient. The feeding of methionine directly to a ruminant is of little value because it is broken down in the rumen and thus is not present as methionine in the intestines where amino acids are absorbed. Methionine-hydroxy-analogue (MHA) is a product that is reportedly not broken down in the rumen but passes to the lower gut where it is absorbed. Therefore, it may be a dietary source of a methionine precursor to the ruminant. If lactating range cows under stress are deficient in methionine, then supplementation with MHA may fulfill the deficiency, particularly with supplements containing NPN.

The purpose of this trial was to compare the utilization of NPN from Kedlor, biuret and urea in range supplements and to determine the effects of adding MHA and high levels of dehydrated alfalfa to range supplements containing high levels of urea or biuret.

Procedure

The trial was conducted at the Lake Carl Blackwell Range located 10 miles west of Stillwater. The predominant forage is of the tallgrass prairie type with climax species consisting of little bluestem, big bluestem, Indian and switch grass. Since the grasses were dormant during the wintering trial, the major portion of the cows' diet consisted of dry weathered grass. Prairie hay was fed only on a few occasions when snow covered the range forage.

The experimental cattle were 82 mature Hereford and Angus cows 6 to 8 years of age which were maintained in one pasture and 58 Hereford heifers calving for the first time which were maintained in a different pasture. The calving dates were November 22, 1971 to March 2, 1972 for the mature Angus and Hereford cows and October 6, 1971 to January 25, 1972 for the Hereford heifers. The experiment was conducted during an 88-day period from December 28, 1971 to March 25, 1972.

The ingredient makeup of the supplement is shown in Table 1. Two of the supplements (1 and 2) contained all natural protein; supplement 1 contained 15 percent crude protein and supplement 2 contained 30 percent protein. The remaining nine supplements contained 30 per-

Table 1. Ingredient Make-up of Supplements (Percent)

Ingredient	Supplement										
	1	2	3	4	5	6H[1]	7H[1]	6C[2]	7C[2]	8	9
	Negative Control Natural	Positive Control Natural	Kedlor	Biuret	Urea	Biuret +MHA	Urea +MHA	Biuret +MHA	Urea +MHA	Biuret + Alfalfa	Urea + Alfalfa
	15	30	30	30	30	30	30	30	30	30	30
Alfalfa, dehydrated	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	40.0	40.0
Milo	64.3	23.8	53.5	53.2	55.1	53.3	55.1	52.8	54.7	27.5	29.4
Molasses, blackstrap	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Soybean meal (44%)	16.9	57.5	19.3	19.3	18.8	19.2	18.8	19.3	18.9	10.5	10.1
Wheat middlings	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Kedlor	---	---	6.46	---	---	---	---	---	---	---	---
Biuret	---	---	---	6.73	---	6.73	---	6.73	---	6.73	---
Urea	---	---	---	---	5.31	---	5.31	---	5.31	---	5.31
Dicalcium phosphate	1.13	0.73	1.12	1.12	1.12	1.12	1.12	1.12	1.12	---	---
Monosodium phosphate	2.58	2.36	2.67	2.67	2.66	2.67	2.65	2.67	2.66	3.67	3.66
Sodium sulfate	---	0.63	1.97	1.97	1.97	0.75	0.75	0.75	0.75	1.59	1.59
Trace minerals	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
MHA[3]	---	---	---	---	---	1.185	1.185	1.58	1.58	---	---

[1] Fed to Hereford heifers.
[2] Fed to mature Hereford and Angus cows.
[3] Methionine-hydroxy-analogue provided 10 gm/head/day before calving and 20 gm/head/day after calving.

cent crude protein equivalent; one-half of the total protein, or 15 percent, consisted of natural protein whereas urea, biuret or Kedlor furnished the remaining 15 percent (one-half of the protein equivalent).

Supplement 1, the negative control, served two purposes. First, the difference in performance between cows receiving supplement 2 (30 percent protein) and supplement 1 (15 percent protein) would indicate if additional protein were needed beyond that provided by supplement 1. Second, the performance of cows fed supplements 3 through 11, in comparison to cows on supplements 1 and 2, would provide some indication of the degree of utilization of the NPN sources. The supplements were formulated to contain 1.25 percent phosphorus, 0.5 percent calcium and a nitrogen: sulphur ratio of 14:1. The MHA was added to provide 10 grams per head per day before calving and 20 grams per head per day after calving. The supplements were processed into ¼ inch pellets and were fed 6 days per week. Supplement was not fed on Sundays or on a few days when snow or ice covered the ground in which case only prairie hay was fed. The supplements were fed individually which allowed all of the cows in each group to occupy the same pasture thereby eliminating the effects of different pastures. The amount of supplement fed per cow per feeding was as follows:

	Before Calving	After Calving
Hereford heifers, lb	2.33	4.67
Mature Hereford and Angus cows, lb.	1.75	3.50

Some of the supplements were not palatable and the cows did not consume the entire amount offered. The amount of feed refused was weighed each day and discounted from feed intake.

At the initiation and conclusion of the experiment the cows were scored for condition on a scale of 1 to 9 with 1 being the thinnest and 9 the fattest.

The calves from the mature Hereford and Angus cows were sired by Charolais bulls and the calves out of the Hereford heifers were sired by Hereford bulls. Both the mature cows and Hereford heifers were artificially inseminated starting January 12, 1972 and January 8, 1972, respectively. After approximately 42 days of artificial inseminating, clean-up bulls were turned with the cows for the remainder of the breeding season. The calves from the Hereford heifers were weaned July 10, 1972 and the calves from the mature cows were weaned August 15, 1972. Weaning weights were adjusted to a 205-day basis and to a steer equivalent by multiplying the 205-day weight of the heifers by 1.05. The calves were

Table 2. Winter Weight and Condition Score of Cows

Item	Supplement								
	1 Negative Control Natural 15	2 Positive Control Natural 30	3 Kedlor 30	4 Biuret 30	5 Urea 30	6 Biuret +MHA 30	7 Urea +MHA 30	8 Biuret+ Alfalfa 30	9 Urea+ Alfalfa 30
					Hereford and Angus Cows				
Number cows	10	10	10	8	10	7	9	9	9
Weight per cow, lb.									
Initial[1] (12-28-71)	1060	1051	999	1061	1096	1099	1057	1114	1046
Final (3-25-72)	782	810	777	801	828	826	776	843	798
Weight loss	278	241	222	260	268	272	281	270	248
Percent loss	26.2	22.9	22.2	24.5	24.5	24.7	26.5	24.2	23.7
No. cows calved before experiment	3	3	3	3	3	3	2	5	4
Condition score									
Initial	4.8	5.0	4.4	4.5	5.0	5.1	4.9	5.2	4.9
Final	2.4	3.3	2.6	2.4	2.8	3.1	2.6	3.1	3.1
Loss	2.4	1.7	1.8	2.1	2.2	2.0	2.3	2.1	1.8
					Hereford Heifers				
Number heifers	7	6	7	7	6	7	6	6	6
Weight per cow, lb.									
Initial (12-28-72)	852	916	834	874	875	904	909	845	863
Final (3-25-72)	730	822	716	753	741	784	756	733	740
Weight loss	122	94	119	121	134	119	153	113	123
Percent loss	14.3	10.3	14.3	13.8	15.3	13.2	16.8	13.4	14.3
Condition score									
Initial	5.3	5.7	4.7	5.3	5.3	5.4	5.2	5.3	5.2
Final	3.3	3.8	2.5	3.1	2.8	3.1	2.7	3.2	2.8
Loss	2.0	1.9	2.2	2.2	2.5	2.3	2.5	2.1	2.4

[1] Initial weights of cows that calved before treatment started were adjusted to pregnant cow basis by dividing calf birth weight by .589 for bull calves and .568 for heifer calves and adding this correction factor for calving loss to the actual initial weight of the cow.

creep-fed with dehydrated alfalfa pellets in late winter (January, February and March).

Results and Discussion

Cow weight and condition score changes are shown in Table 1. The percent weight loss (which included calving loss) for the mature Angus and Hereford cows was relatively high in all treatments. The 15 percent natural-protein supplement resulted in 3.3 percent more weight loss than the 30 percent natural-protein supplement. The cows receiving the Kedlor supplement lost about the same percent of weight as the positive control cows. The percent weight loss of mature cows on other NPN treatments (except urea plus MHA) was intermediate between negative and positive controls (15 percent and 30 percent natural), suggesting a partial utilization of the NPN in the supplements. Trends in weight loss in the Hereford heifers were similar to those observed in the mature cows. The heifers consuming the natural 30 percent protein supplement lost less weight than heifers on all other treatments. In general, percent weight loss on NPN treatment was similar to that of heifers on the negative control, indicating little utilization of the NPN in the supplements.

The condition scores of the mature cows at the end of the trial were not significantly different, although the cows on the natural 30 percent protein supplement appeared to be in the best condition and the cows on the natural 15 percent protein supplement in the poorest condition. The change in condition of the Hereford heifers followed a similar pattern for the positive control and NPN treatments. However, the loss in condition of the heifers on the negative control was relatively smaller.

This trial did not indicate any benefit from the addition of MHA to urea or biuret supplements. The supplement intake data (Table 4) indicated that MHA lowered the palatability of the supplement when added to both urea and biuret. The intake of the urea supplement was especially reduced by MHA.

High levels (40 percent of the supplement) of dehydrated alfalfa meal did not appear to increase urea or biuret utilization; the advantage in winter weight change of cows on the urea supplement with alfalfa over those on urea without alfalfa was small.

The performance of the calves and the fertility of the cows are shown in Table 3. It is doubtful that the treatments had any effect on the performance of the calves. The average daily gain of the calves while on treatment and adjusted weaning weights did not follow any pattern. For example, the performance of the calves from the cows on the natural 15 percent protein was the highest of all treatments for the mature cows and the lowest for the Hereford heifers. It is doubtful that creep-feeding

Table 3. Performance of Calves Born During Winter and Rebreeding Performance of Cows

Item	Supplement								
	1	2	3	4	5	6	7	8	9
	Negative Control Natural	Positive Control Natural	Kedlor	Biuret	Urea	Biuret +MHA	Urea +MHA	Biuret+ Alfalfa	Urea+ Alfalfa
	15	30	30	30	30	30	30	30	30
Hereford and Angus Cows									
No. cows calved[1]	10	10	10	8	10	7	8	9	9
Calving date	Jan 13	Jan 17	Jan 2	Jan 2	Jan 4	Dec 31	Dec 31	Jan 1	Jan 1
Birth weight[2], lb.	84	76	74	84	81	86	80	78	78
Daily gain									
Birth to 4-7-72, lb.	1.43	1.33	1.26	1.47	1.34	1.28	1.25	1.35	1.22
Weaning weight[3]	524	512	489	543	522	524	508	502	488
No. cows open 8-15-72	1	2	0	0	2	2	1	0	1
Hereford Heifers									
No. cows calved[1]	7	6	7	7	6	7	6	6	6
Calving date	Nov 9	Nov 6	Nov 21	Nov. 2	Nov. 4	Nov 15	Nov 12	Nov 7	Oct 30
Birth weight, lb.[2]	65	71	63	72	69	66	72	68	63
Daily gain									
Birth to 4-7-72, lb.	0.80	0.91	0.87	0.79	0.99	0.92	0.79	0.89	1.03
Weaning weight	331	360	353	329	373	361	338	356	362
No. cows open 7-10-72	1	1	2	2	2	2	1	0	0

[1] Includes cows that raised calves to weaning.
[2] Heifer calves adjusted to bull equivalent by multiplying actual birth weight by 1.048.
[3] Weaning weight adjusted to 205 days of age and to steer basis (heifer weight x 1.05).

Table 4. Supplement Intake

Item	1 Negative Control 15	2 Positive Control 30	3 Kedlor 30	4 Biuret 30	5 Urea 30	6 Biuret +MHA 30	7 Urea +MHA 30	8 Biuret+ Alfalfa 30	9 Urea+ Alfalfa 30
				Hereford and Angus Cows					
Number cows	10	10	10	8	10	7	8	9	9
Supplement									
Offered, lb./hd/d	2.63	2.58	2.78	2.79	2.76	2.72	2.74	2.74	2.74
Consumed, lb/hd/d	2.63	2.58	2.78	2.79	2.46	2.64	1.93	2.74	2.53
Percent refused	0	0	0	0	11.0	2.9	29.8	0	7.6
No. of cows refusing supplement	0	0	0	0	8	3	8	0	6
				Hereford Heifers					
Number cows	7	6	7	7	6	7	6	6	6
Supplement									
Offered, lb.	3.93	3.93	3.92	3.93	3.93	3.89	3.93	3.93	3.93
Consumed, lb.	3.93	3.93	3.11	3.87	3.71	3.57	3.04	3.93	3.64
Percent refused	0	0	0.2	15.4	5.5	8.2	22.5	0	7.2
No. cows refusing supplement	0	0	2	2	5	6	6	0	6

masked treatment effects, since the average consumption of dehydrated alfalfa pellets was only 22 and 62 pounds per calf from the mature cows and Hereford heifers, respectively.

With the limited number of cows per treatment, it was difficult to make definite conclusions regarding rebreeding performance.

As previously mentioned, urea lowered palatability. Also, MHA decreased the palatability of both urea and biuret supplements. Part of the palatability problem was apparently due to lack of competition among the individually fed cows. Supplement 5 (the urea supplement) was group-fed to crossbred Angus x Holstein cows at higher levels than fed in this trial and was commonly consumed in 12 minutes. The same supplement was not completely consumed by all individually fed cows when allowed 20 minutes to eat. There also appeared to be differences in preference among cows.

Conclusions

This trial indicated poor utilization of the NPN in winter supplements for range cows. The addition of MHA or high levels of dehydrated alfalfa meal to urea and biuret supplements did not result in improved cow performance. The MHA decreased the palatability of biuret supplements slightly and urea supplements considerably.

Liquid Protein Supplement vs. Dry Natural-Protein Supplement For Wintering Heifer Calves

Ivan Rush, Ray Helderman, W. E. Sharp and Robert Totusek

Story in Brief

A liquid supplement (self-fed) was compared to a dry natural-protein supplement (self-fed, with added salt as the intake-limiting ingredient) for heifer calves wintered on dry native grass. Calves consuming liquid supplement lost 77 lb. during the wintering period while those fed the natural-protein supplement lost 54 lb. On the basis of prices used, the liquid supplement had an advantage of $0.91 in winter supplement cost, but a disadvantage of $8.05 in value of winter weight change.

Introduction

The use of liquid supplements to provide additional energy, protein and other nutrients has increased in recent years. Perhaps the major advantage of liquid supplements has been the saving in labor to the cattleman. They are self-fed, plus in most cases they are delivered directly to the pasture. Most liquid supplements contain a molasses base with urea added to supply the major portion of the nitrogen or crude protein equivalent. Previous research at Oklahoma State University has suggested a low utilization of urea with low quality roughage; it is questionable if enough urea is being utilized to meet the protein requirements through synthesis of microbial protein.

Previous research has also shown that additional energy supplied by molasses has very little if any benefit if the animal is in a protein deficient state. In view of these and other problems associated with the feeding of liquid supplements with low quality forages, their actual value should be fully determined.

The purpose of this trial was to compare a liquid protein supplement with a self-fed dry natural-protein supplement for heifer calves grazing low quality roughage during the winter.

Appreciation is expressed to the Prolix Company, Box 423, Aliceville, Alabama, and Harry Overbeck and Tom Harris, T Bar H Liquid Feeds, Cushing, Oklahoma, for supplying the liquid supplement.

Procedure

The experiment was conducted at the Lake Carl Blackwell Range located 10 miles west of Stillwater. The predominant forage is of tall-grass prairie type with climax species consisting of little blue stem, Indian and switch grasses. Since these grasses were dormant during the winter trial, the major portion of the diet consisted of dry weathered grass. Prairie hay was fed only on a few occasions when snow covered the range forage.

The experimental cattle consisted of 44 crossbred Charolais x Angus and Charolais x Hereford heifers 8-10 months of age. They were randomly allotted to two groups. These calves had been weaned 9-22-71. The experiment was initiated 11-18-71 and terminated 3-29-72, a 132-day period. Two pastures were used and the cattle were rotated at the time they were weighed which was at approximately 28-day intervals.

The liquid supplement was a commercial mix that contained 35 percent crude protein and was self-fed. The natural-protein supplement contained 30 percent crude protein. The ingredient makeup of the natural-protein supplement was as follows:

Ingredient	Percent of Formula
Milo	23.80
Soybean meal (44%)	57.43
Dehydrated alfalfa meal	5.00
Molasses, blackstrap	5.00
Wheat middlings	5.00
Monosodium phosphate	2.36
Dicalcium phosphate	.73
Sodium sulfate	.63
Trace minerals	.05
	100.00

Vitamin A to provide 10,000 IU/lb. of supplement.

Salt was used to limit the intake of the natural-protein supplement. The salt level to limit the intake varied from 17 to 27 percent and the average salt level for the entire period was 23 percent. It was not possible to maintain comparable intake of the two supplements at all times during the trial. Consumption of the natural-protein supplement was relatively high early in the trial so its subsequent intake had to be restricted by increasing the level of salt. However, the amount of crude protein consumed per head for the entire feeding period was equal for the two supplements.

The calves were scored for condition at the start and finish of the trial.

Results and Discussion

The summary of the performance of the calves can be seen in Table 1. The heifers consuming the liquid supplement lost 77 pounds while those on the natural-protein supplement lost 54 pounds, a 23 pound difference (statistically significant, $P<.005$), during the 123-day treatment period. After 57 days on trial the weight loss of the two groups of heifers was approximately equal and it was only during the last 75 days that the difference in weight loss occurred. The reason is not clear because the consumption of liquid supplement was higher than natural-protein supplement during the last 75 days. This is in contrast to the earlier part of the trial when the consumption of the natural-protein supplement was at a higher level than that of the liquid supplement.

The condition of the cattle as measured by condition score was not influenced by kind of supplement.

The consumption of the liquid and dry natural-protein supplements was approximately 1.0 and 1.15 lb. per head daily, respectively. Crude protein intake was 0.35 per head daily for both groups. In addition, 0.34 lb of salt per head daily was consumed by the calves fed the natural-protein supplement.

An economic analysis is shown in Table 2. On the basis of price assumptions which were used, the total winter cost of liquid protein supplement was $0.91 less than for the dry natural-protein supplement. However, the heifers fed natural protein had a 23 lb. advantage in winter weight change which was worth $8.05 at $0.35 per pound; the natural-protein supplement had a net financial advantage of $7.14. Prices

Table 1. Weight, Condition Score and Supplement Intake (Winter 1971-72, 132 Days)

	Supplement and % Crude Protein	
Item	Natural 30	Liquid 35
Number heifers	22	22
Initial weight, lb.	579	569
Final weight, lb.	525	492
Weight lost, lb.	54***	77***
Condition score[1]		
Initial	6.04	5.86
Final	3.05	2.88
Supplement consumed		
Supplement/head/day, lb.	1.15[2]	1.00
Crude protein/head/day, lb.	.35	.35

[1] On a scale of 1-9, with 1 the thinnest and 9 the fattest.
[2] Protein supplement consumed. In addition, 0.34 lb. salt/head/day was also consumed.
***Means were significantly different from each other ($P<.005$).

Table 2. Economic Analysis

Item	Supplement and % Crude Protein Natural 30	Liquid 35
Cost/ton, $	80.00[1]	85.00
Cost/lb. crude protein, $	.1330	.1130
Supplement cost/head/day, $	.0460	.0425
Cost of salt/head/day, $	.0034	--
Total supplement cost/head/day, $	.0494	.0425
Total supplement cost/head, 132 days, $	6.52	5.61
Advantage in total supplement cost, $		0.91
Advantage in winter weight change, lb.	23	
Value at $0.35 per lb., $	8.05	
Net advantage, $	7.14	

[1] Includes the cost of the protein supplement. Salt was mixed at various proportions to control intake. The average consumption of salt was .34 pounds per head per day.

used were those current when the trial was conducted during the winter of 1971-72; different prices can be substituted as appropriate in each individual projection.

Conclusions

The results of this trial indicate that a liquid supplement can be used to winter calves on dry native grass, but that a lower level of performance should be expected compared to that obtained with a natural-protein supplement.

Self-Feeding vs. Six Or Three Times Per Week Feeding Of High Urea Winter Supplements To Range Cows

Ivan Rush, Ray Helderman, W. E. Sharp and Robert Totusek

Story in Brief

A 30 percent protein supplement with one-half of the protein equivalent from urea was provided for Angus x Holstein crossbred cows wintered on dry native grass. The supplement was (1) self-fed (with salt to limit intake), or (2) fed six times per week, or (3) fed three times per week; the weekly intake of supplement was similar among treatments. Although self-fed cows lost less winter weight, differences were small and other observations indicated no marked detrimental effects from feeding the urea-containing supplement six times per week or even three times per week.

Observations on the supplement feeding patterns of the cows showed that (1) cows self-fed ate supplement 3.4 times per day for a total of 34 min., (2) cows fed six times per week consumed their supplement allowance in 12 min., and (3) cows fed three times per week required three feedings in 8.2 hours and ate a total of 62 min. to consume their supplement allowance.

High winter weight loss and poor rebreeding performance of cows indicated that urea utilization was poor in all treatments.

Introduction

One way that a cattleman can lower the cost of wintering cattle is to lower the labor requirement of feeding. Not only is the cost of labor increasing, but the availability of qualified personnel for ranch work is decreasing, so cattlemen are presently attempting to maintain more cattle per man. Research at the Oklahoma Agricultural Experiment Station has shown that cattle do not require daily protein supplementation but can be fed larger quantities 2 or 3 times per week with no sacrifice in performance. The previous research was done with natural protein supplements. Today there is economic pressure to feed larger quantities of urea and other non-protein-nitrogen sources, but there has been no research concerning the frequency of feeding of range supplements that contain high levels of urea.

Theoretically, based on laboratory and metabolism research, urea consumed in small amounts at frequent intervals should be utilized better than larger quantities consumed less frequently. This suggests that self-feeding should be most desirable and two or three times per week feeding should be least desirable. Furthermore, the less frequent feeding of larger quantities of urea supplements suggests a question concerning a possible hazard of urea toxicity.

Procedure

The experiment was conducted at Lake Carl Blackwell Range located 10 miles west of Stillwater, Oklahoma. The predominant forage is of the tall grass prairie type with climax species consisting of little bluestem, tall bluestem, Indian and switch grass. Since these grasses were dormant during the winter trial the major portion of the cows' diet consisted of dry weathered grass. Prairie hay was fed only on a few occasions when snow covered the range forage.

The experimental cattle were crossbred Angus x Holstein cows, 4 and 5 years old at the beginning of the trial. All cows in the trial were bred to Hereford bulls. The cows started calving December 1, 1971 and finished March 3, 1972, a 94 day period.

The experiment was conducted during a 123 day period from November 19, 1971 to March 21, 1972. The experiment consisted of six groups of cows with two groups randomly assigned to each of three treatments. Treatment 1 involved self-feeding the supplement; salt was mixed with the supplement to limit its intake. The cattle on Treatment 2 were fed 6 times per week while those on Treatment 3 were fed 3 times per week. The amount of self-fed supplement consumed wsa calculated each week and this quantity was fed in the hand-fed groups the following week. This allowed all groups of cows to consume approximately the same amount of supplement during the trial. The groups of cattle were rotated among the six experimental pastures at approximately 28-day intervals to minimize differences in performance due to possible pasture differences.

The ingredient makeup of the protein supplement was as follows:

Ingredient	Percent of Formula
Milo	55.10
Soybean meal (44%)	18.79
Alfalfa, dehydrated	5.00
Molasses, blackstrap	5.00
Wheat middlings	5.00
Urea (45% N)	5.31
Dicalcium phosphate	1.12
Monosodium phosphate	2.66
Sodium sulfate	1.97
Trace minerals	.05
	100.00

Vitamin A—added to supply 10,000 IU/lb. of supplement.

The supplement was formulated to contain 30 percent crude protein with urea furnishing one-half of the crude protein equivalent. The intended intake was 3 lb. per head per day before the majority of the cows calved. To regulate intake the level of salt ranged from 25 to 33 percent; the average level during the trial was 28 percent of the supplement mixture.

The supplements which were hand-fed six and three times per week were initially processed into a ¾ inch range cube and fed on the grass. At a later mixing some problems were encountered in making the large cube, so a ⅝ inch pellet was made and this was fed in feed bunks.

Supplement intake patterns were observed on all groups during two 24-hour periods in March. The self-feeders were observed for 24 continuous hours and the time of day and duration of supplement feeding of each cow was recorded. The hand-fed groups were observed until all supplement was consumed.

Calves were weaned and weighed August 10, 1972; weaning weights were adjusted for age of calf, sex of calf and age of dam.

Results and Discussion

A summary of the amount of supplement consumed and the weights and condition of the cows is shown in Table 1. The cows that were self-fed lost less weight than the cows that were fed six or three times

Table 1. Cow Weight, Cow Condition Score and Supplement Consumption (Winter 71-72)

	Frequency of Feeding		
	Self-Fed	Six Times Per Week	Three Times Per Week
No. cows	16	18	17
Weight			
Initial, 11-19-71, lb.	1164	1135	1109
End of winter, 3-21-72, lb.	876	817	806
Winter loss, lb.	288	318	303
Winter loss, %	24.8	28.2	27.3
Fall, 8-10-72, lb.	1050	1109	1110
Condition score[1]			
Initial, 11-19-71	5.19	5.17	4.94
End of winter, 3-21-72	1.81	1.78	1.47
Change	3.38	3.39	3.47
Supplement per cow daily, lb.	3.29[2]	3.32	3.40

[1] On a scale of 1 to 9 with 1 the thinnest and 9 the fattest.

[2] Pounds of protein supplement consumed. In addition, 1.28 pounds of salt were consumed/head/day

per week, and the cattle fed three times per week lost slightly less than those fed six times per week; differences in weight changes among treatments were not statistically significant ($P<.05$). The weight loss of cows on all treatments was higher than desired on cows of this age and the cows became very thin by the end of the trial.

Cattle fed three times per week were slightly thinner in condition at the end of the trial than cows that were self-fed or fed six times per week. The thin condition cows on all treatments is reflected in the poor conception rate shown in Table 2; all groups are below an acceptable fertility level.

These observations on weight loss, condition and rebreeding suggest that the utilization of urea was low; comparable levels of an all-natural-protein supplement fed to the same cows a year earlier resulted in less weight loss and much better rebreeding performance.

The performance of the calves (Table 2) did not appear to be greatly affected by the treatments. The trends in calf performance were in contrast to cow weight changes. The calves from cows fed three times per week had a higher average daily gain while on treatment and from birth to weaning plus a higher adjusted weaning weight; calves from self-fed cows had the lowest average daily gain and adjusted weaning weights.

Part of the difference in calf performance can be explained by the differences in date of calving (which was unrelated to winter treatment in this trial). Self-fed cows calved 17 and 10 days earlier than those fed three and six times per week, respectively; calves that were on the winter treatment the longest had the poorest performance. It is also

Table 2. Performance of Calves and Rebreeding Performance of Cows (Winter 1971-72)

	Frequency of Feeding		
	Self-Fed	Six Times Per Week	Three Times Per Week
No. cows	16	18	17
Avg. calving date	Jan. 6	Jan. 16	Jan. 23
Birth wt.,[1] lb.	78	81	84
Wt. of calves 3-21-72, lb.	202	200	193
Daily gain to 3-21-72, lb.	1.70	1.88	1.93
Weaning wt.[2], lb.	561	592	595
Condition score[3] of calves	6.38	6.39	6.53
No. of cows rebred	12	12	12
Percent cows rebred	75	67	71

[1] Heifer calves adjusted to bull equivalent by multiplying actual birth weight by 1.048.
[2] Weaning weight adjusted to 205-day, steer, mature dam basis.
[3] On a scale of 1-9 with 1 the thinnest and 9 the fattest.

possible that due to chance the treatment groups were unequal in genetic ability for cow productivity. Certainly there would be no reason to expect cows with greater winter weight loss to produce heavier calves. The condition of the calves at weaning did not appear to be affected by the winter treatments.

The supplement feeding patterns of the cows are shown in Table 3. Self-fed cows ate supplement an average of 3.4 times per day and a total of 34 minutes for the 24-hour period, an average of 10 minutes at each feeding. During the 24-hour period when observed they consumed approximately 5 lb. of supplement which included 2.15 lb. of salt; the supplement mix contained 30 percent salt during the days of observation. The cattle fed six times per week consumed the same quantity of pelleted supplement in 12 minutes.

It was interesting to note that when the cows fed three times per week were fed 10 lb. per head they did not eat the entire amount at one time, but ate the supplement very slowly for 10 to 20 minutes and then grazed for a period of time before returning for more supplement. Their supplement contained no salt to limit intake. On the average a cow ate the supplement at three different times in 8.2 hours with a total eating time of 62 minutes. This suggests that the unpalatable urea limited the intake or that possibly some feed-back mechanism, developed from prolonged feeding of urea, stopped the cattle from eating toxic levels of urea.

Table 3. Frequency and Time of Supplement Feeding (Winter 71-72)

	Frequency of Feeding		
	Self-Fed	Six Times Per Week	Three Times Per Week
First 24-hr. observation, 3-3-72			
Eating time/head/day, min.	39	10	61
No. times ate/day	4.1	1.0	3.0
Time feed was available, hr.	24	--	8.3
Amount consumed, lb.	5.44	5.0	10.0
Second 24-hr. observation, 3-10-72			
Eating time/head/day, min.	29	14	62
No. times ate/day	2.7	1.0	3.1
Time feed was available, hr.	24	--	8.1
Amount consumed, lb.	4.65	5.0	10.0
Both 24-hr. observations			
Eating time/head/day, min.	34	12	62
No. times ate/day	3.4	1.0	3.1
Time feed was available, hr.	24	--	8.2
Amount consumed, lb.	5.04	5.0	10.0

It should be emphasized that the cattle had been fed supplement for approximately 3 months before these observations were taken. Oklahoma State University research has shown that about 20 gm of urea per 100 lb. body weight in a single dose to unadapted cows will cause death. In this trial, the cows fed six times per week received a maximum of about 15 gm urea per 100 lb. body weight at a feeding (consumed in about 12 minutes). The cows fed three times per week received a maximum of about 30 gm per 100 lb. body weight at a feeding, but the supplement was consumed at three different times during 8.2 hours.

This intermittent consumption of supplement, somewhat similar to the feeding pattern exhibited by the self-fed cows, may explain why the performance of these cows was not at a lower level. Furthermore, at the start of the trial the cows were gradually switched from six to three times per week feeding during a 2-week period.

Conclusion

This trial suggested a slight improvement in utilization of urea from self-feeding the supplement, as indicated by cow weight loss, but urea containing supplements were hand-fed six or three times per week without serious consequences. High weight losses and poor rebreeding performance suggested poor utilization of urea in all treatments.

Selection of Cows for the Breeding Herd
I. Value of a Female's Own Growth Record

A. C. Boston, J. V. Whiteman and R. R. Frahm

Story in Brief

The records of 680 Angus cows and their 2,664 calves and 183 Hereford cows and their 634 calves were studied to determine the relative merit of different measures in predicting the average weaning weight of the calves that a cow produced. The measures were (1) the heifer's own 205-day weaning weight and (2) her yearling weight (about 14 months). The data came from fourteen years of records of two beef cattle breeding herds, one at the Fort Reno Livestock Research Station and one at the Lake Carl Blackwell range area west of Stillwater. All Weight records were corrected for age of calf at weaning, age of dam and sex and the average effects of years and herds were removed.

The value of a female's own record in predicting the record of her calves was evaluated in terms of a statistic called a regression coefficient. (This statistic indicates how the calves' records respond in relation to the cow's record. Example: If a regression coefficient is .2, this means that the calf's weaning weight tended to be about .2 pounds heavier than average for every pound that the cow's record was heavier than average. Also, if a cow's own weaning weight was lighter than average, her calf's weaning weight was .2 pounds lighter for every pound that the cow's record was below average.)

The analyses of these records indicated that if the heifer calves with heavier than average weights at weaning are saved as replacements they can be expected to produce heavier weaning calves than if the lighter heifers had been saved. The data further suggested that this difference would not be large, however. The regression coefficient was .23 for Herefords and .12 for Angus when comparing all calves produced to the weaning weight record made by the cow.

The study also evaluated the merit of the cow's yearling weight as a predictor of her ability to wean heavy calves. The data suggested that the cow's yearling weight may be a little better predictor. The values obtained suggested that for each pound that a Hereford heifer was heavier than her mates as a yearling, she would produce calves that were .29 lbs. heavier than their mates on the average throughout her life. The value for Angus was .14 again suggesting that these relationships are lower in Angus than in Hereford females.

In cooperation with USDA Agricultural Research Service, Southern Region.

Introduction

There is a great amount of variation in the weight of different calves at weaning time. Further, it is easy to show that some cows consistently produce much heavier calves than others. It would be most fortunate if the cattlemen could know which heifers would become the producers of the heavier calves so that he could keep these for replacements.

There is presently some concern about the idea that if a young heifer becomes too fat her own milk producing ability may be damaged. If this is true, the heavier heifers at weaning (which would tend to be the fatter ones) might not themselves become the best cows in the next generation.

This study was undertaken to determine from typical Hereford and Angus cow production records (1) how valuable a cow's own growth performance as measured up to weaning and as a yearling is in predicting her producing ability as a cow and (2) whether there was a realistic problem regarding damage to a heifer whose mother gave enough milk to make her heavier at weaning.

Experimental Procedure

The weaning and yearling weights were collected from 1958 through 1971 as part of two beef cattle selection projects. These projects were located at the Lake Carl Blackwell Range west of Stillwater and the Fort Reno Livestock Research Station, El Reno. From these 14 calf crops, the weaning weights of 2,664 calves from 680 Angus and of 634 calves from 183 Hereford cows were studied. All cattle were purebred or straight-breds. The cows were born from 1956 through 1969. There were weaning weights available on 573 of the Angus and 162 of the Hereford cows when they were calves and yearling weights were present on 427 of the Angus and 144 of the Herefords. The averages of these various weights are reported for each breed in Table 1.

The cattle in this study are considered to be representative samples of the two breeds. Therefore, it is felt that the genetic base is broad enough in both breeds that the results of this study are characteristic of these breeds.

The cow herds were managed similar to local progressive beef herds under a native range, spring calving program. Wheat pasture was utilized by the cows after weaning when available. The cows were supplemented in the winter when on dormant range with up to 3 pounds daily of cottonseed cake. After calving, alfalfa and prairie hay were also fed. The amount of supplemental feed depended upon location, year and condition of the cattle. The calves were not creep-fed. Replacement heifers were fed their first winter to gain from 0.5 to 1.0 pounds per head daily.

Table 1. Number of Cattle and Averages by Breed for the Adjusted Weights[1]

Weight	Angus			Hereford		
	No.	Average (lbs.)	S.D.[2] (lbs.)	No.	Average (lbs.)	S.D.[2] (lbs.)
Cow:						
Weaning	573	434	39	162	450	37
Yearling	427	602	60	144	622	64
Calf:						
Weaning	2,664	426	42	634	435	49

[1] Weights were adjusted for age at weaning, age of dam, sex and year.
[2] Standard deviation.

Special effort was made to maintain uniform grazing conditions for all animals at each location.

The females in each herd were allotted to 15 to 30 cow, single sire breeding groups. The breeding season ran from May 1 to July 31. All calves were spring born with the majority coming in February and March. All cows were also spring born. Only calving records of cows 11-years-old and younger which calved first as 2-year-olds were included in this study.

All calves were identified at birth. Depending upon project and location, the male calves were left intact or castrated. About 35% of all males were castrated at about 3 months of age. The calves were weaned and weighed each year at an average of about 205 days, normally late September. The replacement heifers were weighed for long yearling weights just prior to being placed into breeding pastures at approximately 14 months of age. Cows were culled because of poor production, unsoundness, reproductive failures and age.

Measured differences in animal growth are due mainly to genetic or environmental causes. Genetic merit can be most accurately estimated when cattle are managed under similar environmental conditions and when their weights are corrected to a common basis for known environmental differences. The cow and calf weaning weights were corrected by statistical procedures for differences in age at weaning, age of dam, sex, year and herd. The weaning weights were corrected to a 205-day, mature dam and female basis.

The cow and calf traits studied were corrected to 205-day weaning weights of cows and calves and 425-day cow yearling weights.

Results and Discussion

Selection of replacement heifers is normally based primarily on their own weaning weight, condition and conformation and maybe secondarily on yearling traits. The observed or measured relationships between these weights of a cow when she was a heifer and the weaning weights of each of her calves and the average of all her calves was estimated by the statistical procedure of regression coefficients.[1] A larger coefficient indicates a larger influence, a value of zero indicates no influence and a negative value indicates a negative influence. (If the heaviest heifers at weaning were severly damaged as potential producers of milk, they would produce lighter than average calves and this regression coefficient would be negative.)

In Table 2 the relationships between a cow's own weaning weight and that of her calves is presented. The columns headed *b* present the estimates of the various regression coefficients for each breed. For instance, on the first line the value, .15, under Angus indicates the regression coefficient for the weaning weight of the calf born to a two year old

[1] A regression coefficient (symbolized by the letter, b) is a number which represents the average change in a second variable per unit change in the first variable. In this case the first variable is the weaning weight of the cow when she was a calf. If she was above average, how much do we expect her offspring to be above average? The regression coefficient tells how much.

Table 2. Estimates of the Regression Coefficients (b) for the Change in Calves' Weights per Pound Change in a Cow's Own Weaning Weight

Calf Weaning Records[1]	Angus			Hereford		
	No. of Pairs	b	Standard Error (lbs.)	No. of Pairs	b	Standard Error (lbs.)
			Cow Yearling Weight			
2	461	0.15**	0.05	140	0.26*	0.12
3	410	0.07	0.05	118	0.35**	0.13
4	326	0.09	0.06	93	0.15	0.13
5	240	0.16*	0.07	66	0.18	0.13
6	190	0.13	0.07	48	0.24	0.13
7	146	0.04	0.08	39	0.33	0.17
8	112	0.06	0.12	30	0.15	0.18
9	80	0.03	0.10	10	0.31	0.30
10	65	—.02	0.12	4	0.22	0.72
11	29	0.09	0.18			
Average	573	0.12**	0.04	162	0.23*	0.09

**$P<.01$.
*$P<.05$.
[1] The numbers in this column refer to age of cow when the calf was born. Average is the average of all calves of a cow.

heifer. If the cow weighed a pound more than the other heifers in her herd, her first calf is expected to weigh .15 lb. more than the other calves of the same sex and age. The other b values down the column are interpreted similarly relative to calves born to cows of the indicated age. Table 3 presents similar results relative to the cow's yearling weight and the weights of her various calves.

Of these regression coefficients, 39 percent of the Angus and 35 percent of the Hereford estimates were significantly larger than zero.[2] It was also encouraging that 86 percent of the Angus and 100 percent of the Hereford relationship estimates in Tables 2 and 3 were positive. The nonsignificant and negative estimates tended to be those involving older cows with comparatively low numbers of cow-calf pairs. A negative or very low relationship indicates that very little or no progress would be obtained from selection based on the cow trait involved. Thus, the relationship estimates in Tables 2 and 3 indicate that selection based on either or both of the cow weights should result in some increase in weaning weights of calves produced. However, the amount of increase is estimated by these data to be small, especially for Angus.

Tables 2 and 3 indicated no significant differences between corresponding relationship estimates involving cow weaning and yearling

[2] The word significant means that the evidence is strong that the real relationship being estimated is positve.

Table 3. Estimates of the Regression Coefficients (b) for the Change in Calves' Weights Per Pound Change in a Cow's Yearling Weight

Calf Weaning Records[1]	Angus			Hereford		
	No. of Pairs	b	Standard Error (lbs.)	No. of Pairs	b	Standard Error (lbs.)
			Cow Yearling Weight			
2	359	0.13**	0.04	129	0.32*	0.10
3	296	0.09	0.05	102	0.43**	0.13
4	221	0.08	0.06	82	0.13	0.13
5	162	0.20**	0.08	57	0.26*	0.13
6	128	0.15*	0.07	39	0.12	0.13
7	99	0.22*	0.09	28	0.36	0.20
8	65	—.01	0.13	20	0.20	0.27
9	46	0.05	0.12	7	0.48	0.26
10	34	—.01	0.15	4	0.07	0.47
11	8	0.12	0.07			
Average	427	0.14**	0.04	144	0.29**	0.08

**P<.01.
*P<.05.
[1] The numbers in this column refer to age of cow when the calf was born. Average is the average of all calves of a cow.

weights. However, there was a general trend for cow yearling weight estimates to be larger than corresponding ones involving cow weaning weight. This trend was most pronounced in Herefords where these relationships appeared to be larger than in Angus. These results suggested that a cow's yearling weight may be more closely related to the weaning weights of her calves than is her own weaning weight. Thus, selection of replacement heifers might best be accomplished by using their own yearling weights. Yearling weight has been shown to be a better indicator of an animal's inherited growth ability than is weaning weight.

Several researchers have suggested that mothering ability (basically milk production) provided by beef cows for their heifer calves may influence the heifer's own mothering ability. Some have suggested that there is a negative (undesirable) relationship between a cow's milk production and the genetic growth potential that she transmits to her calves. Either or both of these theories might be partial explanations for the low cow-calf weight relationships observed in this study.

Angus cows are generally considered to give more milk than Herefords. Therefore, the additional milk received by the Angus heifer calves could have harmed their cow productivity as compared to the Hereford heifers. Another factor which might have contributed to the observed breed differences in the cow-calf weight relationships is the tendency for Angus cows to allow more than one calf to nurse. This "community" nursing tendency would be expected to decrease the size of these weight relationships. This behavorial trait in Angus probably results in a heifer's pre-yearling growth not being a good indicator of her inherited mothering ability. And it might also result in the weaning weights of a cow's calves not being a good indicator of her true mothering ability.

Selection of Cows for the Breeding Herd. II. Consistency of Cow Productivity as Measured by Calf Weaning Weights

A. C. Boston, R. R. Frahm and J. V. Whiteman

Story in Brief

Several studies have indicated that the weaning weight of a cow's first calf was a better indicator of a cow's future productivity than the cow's own early growth performance. The purpose of this study was to determine the relationship between a cow's early productivity and her subsequent productivity as measured by the weaning weight of her calves. To examine this relationship, the weaning weight records of 2,664 Angus calves from 680 cows and 634 Hereford calves from 183 cows were analyzed.

The repeatability of calf weaning weights from the same cow were found to be 0.27 and 0.50 for Angus and Hereford cows, respectively. This significantly higher repeatability for Hereford cows indicated that Hereford cows were more consistent in their level of productivity as measured by calf weaning weights. Regression coefficient of the weaning weight of a later calf on the weaning weight of an earlier calf indicated a degree of relationship of approximately the same magnitude as the repeatabilities for the two breeds for those calf weaning weights 4 years or less apart. Regression coefficients between weaning records 5 or more years apart were considerably lower. These results indicate that calf weaning weight would be a good indicator of a cow's subsequent productivity for up to 4 years and would have limited value as a predictor of a cow's productivity 5 or more years in the future.

Introduction

The economic contribution of the cow-calf enterprise to Oklahoma's economy is highly dependent on the weaning weight and grade of the calves produced by the approximately 2.2 million beef cows in the state. Total production can be substantially increased if the proportion of cows consistently producing heavy weaning weight calves every year of their productive lives can be increased. Cow-calf production testing programs have made cattlemen aware of the need for improved techniques and breeding plans that will increase cow productivity.

In cooperation with USDA Agricultural Research Service, Southern Region.

Improvement of weaning weights is dependent upon increasing pre-weaning growth potential of calves and the mothering ability (mainly milk production) of the cows. If selection for weaning weight is to be most effective, cow productivity must be accurately estimated at an early age. Although helpful, a cow's own weaning weight and yearling weight performance do not provide very accurate predictions of her future productivity (See preceding article). A more accurate estimate of cow productivity is provided by the weaning performance of the first calf. The purpose of this study was to determine the relationship of a cow's early productivity (early lactations) with her subsequent productivity as measured by the weaning weight of her later calves.

Experimental Procedure

Data from two beef cattle selection projects collected from 1958 to 1971 were used in this study. These projects included cattle at both the Lake Carl Blackwell Range west of Stillwater and the Fort Reno Livestock Research Station at El Reno. Weaning weights from 2,664 Angus calves from 680 cows and 634 Hereford calves from 183 cows were analyzed. The cattle in this study were considered to be representative samples of both breeds and constituted a broad enough genetic base to provide information characteristic of these breeds.

The cow herds were managed similar to local progressive beef herds under a native range grazing program. Wheat pasture was grazed in the winter when available. Alfalfa and/or prairie hay was fed as needed in the winter. Up to 3 lbs. per head daily of cottonseed cake or equivalent protein supplement was fed during the winter with the actual amount being determined by location, year and condition of the cattle. A special effort was made to maintain uniform grazing conditions for all animals at each location.

The females in each herd were allotted to 15 to 30 cow single sire breeding groups. The breeding season ran from May 1 to July 31. All calves were spring born with the majority coming in February and March. Only calving records of cows 11-years-old and younger which calved first as a 2-year-old were included in this study.

All calves were identified and weighed at birth. Approximately 35 percent of the male calves were castrated at about 3 months of age and the other 65 percent were raised as bulls. All calves were raised by the cows on native range without any creep feed and were weaned and weighed at an average age of 205 days, which normally occurred in late September.

Measured differences in calf weaning weights are due mainly to genetic and environmental causes. Genetic merit can be more accurately estimated when cattle are managed under similar environmental conditions and when their weights have been corrected for known non-genetic or environmental factors. The calf weaning weights were corrected by appropriate procedures for differences in age at weaning, age of dam, sex, year and herd. The weaning weights were corrected to a 205-day mature dam and female basis. Sires were considered a random source of variation in this study, and thus, were not corrected for.

Results and Discussion

The average 205-day weaning weights adjusted for age of dam, sex and year effects for 2,664 Angus calves and 634 Hereford calves were 426 and 435 lbs., respectively. The standard deviations for weaning weight were 42 and 49 lbs. for the Angus and Hereford calves, respectively.

The beef cow influences her calves both by the genetic material she contributes to them and by the mothering environment (mostly level of milk production) she provides for them. Thus, calf weaning weight is the measurable expression of these two traits of the cow, and a cow's productivity is measured every time she weans a calf. If a cow tends to produce similar weight calves each year, the first calf would be a reliable measure of future cow productivity. In this case, culling cows based on the weaning weights of her first few calves would be an effective practice for increasing the level of cow productivity in the herd. On the other hand, if the weaning weight of calves produced by the same cow are not very consistent from year to year, then culling cows on the basis of the performance of the first one or two calves would not be an overly effective practice in terms of increasing the average level of cow productivity in the herd.

The degree of consistency or repeatability of cow productivity can be measured by determining the relationships among weaning weight records of calves produced by the same cow. These relationships were determined by the statistical procedures of intraclass correlation (statistically determined as a ratio of variance components which measure the correlation among calves produced by the same cow) and linear regression coefficients. In both cases, larger coefficients indicate a stronger relationship and, thus would indicate a higher degree of consistency in cow productivity from year to year.

Table 1 presents the analysis of variance from which the repeatability of calf weaning weights were calculated. The repeatability estimates (statistically intraclass correlation coefficients) measure the proportion of the total variation (differences) among the calf weaning weights that were caused by permanent (mostly genetic) differences between cows. The total variation is the permanent cow effects plus the temporary differences which are independent and vary from calf to calf produced by the same cow. The important data in Table 1 are the repeatability estimates for Angus and Hereford cows, which were 0.27 and 0.50, respectively.

The 0.50 repeatability estimate obtained for Hereford cows was quite significantly[1] higher than the 0.27 value obtained for Angus. There was apparently more permanent variation (larger differences) among Hereford than Angus cows. A possible factor contributing to these differences as measured by weaning weight is a greater tendency for Angus cows to permit nursing by other calves in addition to her own. A calf's weaning weight is influenced by total milk consumption which, in the case of Angus calves, may not have necessarily been all attributable to its dam. The higher repeatability in Hereford cow performance does indicate a more consistent pattern of productivity. Thus, culling cows on the basis of the weaning weight performance of her first calf or two would be expected to be more effective in Hereford than in Angus cattle.

The very significant[1] differences among cows within herds indicates a substantial amount of genetic differences for cow productivity within each herd and also within each breed (mean square column of Table 1).

Table 2 presents regression coefficients of later calf weaning weight records on earlier weaning weight records from the same cow. These regression coefficients involve pairs of weaning weight records that are separated by different amounts of time, ranging from successive records one year apart to pairs of records eight years apart. Whereas, the intra-

[1] Statistically significant effects or differences indicate the evidence is strong that the estimated effects or differences are real rather than caused by chance variation.

Table 1. Analysis of Variance and Repeatability Estimates of Calf Weaning Weights[1]

Source of Variation	df	Mean Square	Component of Variance
Angus:			
Among herds	4	12841**	18.0
Among cows within herds	675	2777**	422.6
Among calves within cows	1984	1129	1129.4
Repeatability[2] = 0.272 ± .021			
Hereford:			
Among cows	182	4512**	1014.2
Among calves within cows	451	1005	1005.4
Repeatability[2] = 0.502 ± .040			

[1] Average number of calves per cow was 3.91 for Angus and 3.46 for Herefords. There were 5 herds of Angus but only one herd of Herefords.
[2] Repeatability is the intraclass correlation estimate (± its standard error) of the relationship among calf weaning weight records of the same cow. These repeatability estimates were significantly different ($P < .001$).
**$P < .01$.

class correlation estimates of the repeatability of cow productivity considered all weaning weight records of a cow at once, these regression coefficients examine the relationship between specific pairs (years of separation) of weaning weights of calves produced by the same cow. There was a consistant reduction in the magnitude of the regression coefficents as the time interval between records increased for both breeds. For weaning records four years or less apart, the relationship between paired records in the Herefords was significantly higher than in the Angus. When members of the pair of records were separated by five or more years, the relationship was somewhat lower and similar for both breeds. This decreasing trend in the regression coefficients as the time interval between records increased was perhaps due to several factors: (1) changes in management and nutrition practices, (2) weather conditions, (3) genetic quality of sires used, (4) nature of the permanent cow effects due to varying rates of aging and (5) selection of cows which reduces the permanent differences in the cows kept in the herd. These regression coefficients generally indicated that early cow productivity is probably at best only a poor basis for estimating cow productivity more than four years in the future.

The significantly higher repeatabilities of cow productivity of the Hereford cows over the Angus cows for weaning weight records four years or less apart were similar to the differences in repeatability observed between the two breeds using intraclass correlations (Table 1). Probably the most reasonable explanation for the lower relationship among calf weaning weight records of the same cow in Angus than Herefords is

Table 2. Regression Estimates of the Relationship Between Calf Weaning Weight Records of the Same Cow Calculated From Pairs of Records Having Different Years of Separation

Years of Separation[1]	Angus			Hereford		
	No. of Pairs	Regression[1] Coefficient	Standard Error	No. of Pairs	Regression[1] Coefficient	Standard Error
1	1859	0.29**	0.02	408	0.53**	0.04
2	1417	0.26**	0.03	283	0.44**	0.06
3	1043	0.24**	0.03	197	0.47**	0.07
4	748	0.24**	0.04	137	0.42**	0.08
5	501	0.27**	0.04	82	0.28**	0.10
6	309	0.12*	0.05	48	0.17	0.13
7	172	0.13	0.07	19	0.04	0.22
8	72	0.14	0.10	7	0.12	0.30

[1] The linear regression coefficient for later on earlier calf of the same cow.
* $P < .05$.
** $P < .01$.

the previously discussed community nursing behavioral trait in Angus cows. It is generally accepted among cattlemen that Angus cows are more willing to let bum or foster calves nurse than are Hereford cows. Several Angus cows involved in this study have been observed nursing more than one calf at a time even though it was known that they only had one. This behavioral trait tends to cover up permanent differences between cows for calf weaning weight productivity, thus resulting in a lower level of consistency in weaning weight performance of calves from the same cow.

Results from other studies are in agreement with those of this study, and generally, they indicate that weaning weight of a cow's first calf would be a better indicator of her future productivity than either her own weaning weight or yearling weight (see preceding article).

Results from this study clearly show that the weaning weights of a Hereford cow's early calves would be a more accurate indicator of future productivity than would those of Angus cows. Thus, culling Hereford cows whose first calf has a low weaning weight should be more effective in increasing the average level of productivity of the herd than would be the case with Angus. Breeders may be justified in keeping some Angus cows with low initial records (so long as they are not extremely below average) for a second or third calf and cull on the basis of average performance.

Feedlot Nutrition

Influence of Milo Processing Methods on Digestion of Starch in High Concentrate Beef Cattle Rations

D. D. Hinman and R. R. Johnson

Story in Brief

The processing of cereal grains used in feedlot rations is a common practice. These processing methods usually result in increased feed efficiency and at times increased rates of gain. Since the major source of energy from cereal grains is derived from the starch portion, the extent and site of digestion of the starch in high concentrate rations may explain the increased performance from these rations.

The studies discussed in this paper indicate that steam flaking and micronizing milo significantly increased the digestion of starch when fed in a high concentrate ration. There were no differences in site or extent of starch digestion between the steam flaked and micronized milo in the first trial. The second trial indicated that increasing the degree of micronizing slightly increased ruminal digestion of starch. Only small amounts of starch from the heat treated milo rations escaped digestion. However, significant amounts of starch from the dry rolled milo ration were excreted in the feces and thus represented a loss of available energy to the animal.

Introduction

The processing of cereal grains for beef cattle rations has been studied widely in recent years. However, much of the research has been conducted with rations of less than 80 per cent concentrates while most rations presently being fed to feedlot cattle routinely contain 80-90 per cent concentrates. Research reports have shown that several processing techniques for cereal grains have improved the efficiency of utilization of these grains. The digestibility of the ration and the rates of gain were increased by grain processing in some experiments. Others have shown a decreased feed intake and increased feed efficiency due to processing. The most consistent benefit seems to be the increased efficiency of utilization of the ration.

This improvement in efficiency may be due to a change in the pattern of rumen fermentation and/or an increased digestion of the starch portion of the ration. Since the major source of energy from cereal grains is derived from the starch, the site and extent of digestion of starch in cattle fed high concentrate rations may be related to the increased feed efficiency. The ruminant digests starch at two sites, the first being fermentation by the microorganisms in the rumen, and secondly, should some starch escape that process, by enzymatic digestion in the small intestine.

The capacity of this second system may be limited. In most rations almost all the ingested starch is digested by the animal but the site of digestion in a digestive tract may vary with the method by which the grain was prepared. The literature indicates that the amount of starch escaping ruminal fermentation is variable. Therefore, this experiment was conducted to study the influence of grain processing on the site and extent of starch digestion in high milo rations.

Procedures

Four Angus steers were fitted with permanent rumen and abomasal cannulae and were housed in individual pens with slotted floors. They were fed at hour intervals with the use of automatic feeders built for this purpose. This feeding system was used to maintain a constant flow of digesta through the digestive tract to aid in the sampling of ingesta and feces and to permit more accurate estimates of starch movements through the tract. With this system, feed intake was found to be similar to that found under feedlot conditions. Ration composition is given in Table 1. Chromic oxide was added to the ration as an external indicator to facilitate calculation of starch digestibility.

Table 1. Composition of High Milo Rations

Ingredient	%, 90% D.M. basis	
Milo	84.0	
Cottonseed hulls	7.0	
Dehydrated alfalfa meal	3.0	
Supplement	6.0	
Soybean meal		3.3
Urea		0.7
Minerals, vitamins, & additives		1.55
Wheat middlings		0.2
Chromic oxide		0.25

Two trials were conducted to determine the influence of processing method on starch digestion. A commercial milo was processed by the following methods:

Trial 1	Trial 2
Dry rolled	Dry rolled
Micronized (26 lb/bu)	Micronized (32 lb/bu)
Steam flaked (28 lb/bu)	Micronized (25 lb/bu)
Ground	Micronized (18 lb/bu)

The dry rolled milo was prepared by passing milo through rollers set to crack all kernels. The micronized milo was prepared at the various densities by varing the length and degree of dry heat treatment and then passing through rollers under 130 pounds of pressure. Steam flaked grain was held in a steam chamber for 35 minutes and then passed through rollers set to produce a thin flat flake. Ground milo was produced by passing the grain through a hammer mill with a 3/16 inch screen.These rations were then rotated on a time schedule so that each steer received each ration during a given trial.

Samples of abomasal contents and feces were obtained three times daily on two days for each steer on each ration. Starch and chromic oxide determinations were conducted on the abomasal contents and feces and digestibility of starch calculated using the chromic oxide as an external indicator. The amount of starch digested in the rumen, intestines and total digestive tract were calculated.

Results

Trial 1

The summary of data from Trial 1 is shown in Table 2. Daily feed intake was similar for the dry rolled, micronized and steam flaked milo rations, but the feed intake for the ground milo ration was considerably lower than for the other rations. This was probably due to the fineness of the ground milo resulting in a reduced palatability. Starch intakes reflected the feed intakes as starch contents of the rations were similar. The percent ruminal digestion of starch was not significantly different ($P>.05$) between rations. However, the starch digestion in the total tract was significantly lower ($P<.05$) for the dry rolled milo ration than for the other rations and this trend is also evident in the digestibility of the starch entering the intestines.

These data indicate that heat and pressure treating (steam flaking and micronizing) of milo increased the digestibility of the starch portion of the ration. The ground milo ration also had a higher digestibility of starch than the dry rolled ration but interpretation of this difference is

Table 2. Ruminal, Intestinal and Total Digestion of Starch in Trial 1

Item	Grain processing methods			
	Dry Rolled	Micronized	Steam Flaked	Ground
Feed intake, g D.M./day	5698	5187	5659	4260
Starch intake, g/day	3722	3382	3737	2687
Ruminal digestion of starch, g/day	2847	2848	3038	2319
Intestinal digestion of starch, g/day	592	520	661	336
Starch in feces, g/day	283	14	38	32
Total digestion of starch, g/day	3439	3368	3699	2655
Ruminal digestion, % of total starch intake	76.5	84.2	81.3	86.3
Intestinal digestion, % of starch entering intestine	67.7[1]	87.2[2]	95.4[2]	89.5[2]
Total digestion, % of total starch intake	92.4[1]	99.6[2]	99.0[2]	98.8[2]

[1,2] Values on the same line with different superscripts are significantly different ($P < .05$).

difficult since the level of starch intake was considerably lower with the ground milo.

Trial 2

A summary of data from trial 2 is shown in Table 3. Feed intakes of the four rations in this trial were very similar. There tended to be a slightly higher feed intake for the micronized milo rations indicating that micronization was not detrimental to palatability under these feeding conditions. Ruminal digestion of starch tended to increase as degree of micronization increased, however, these differences were not statistically significant. The largest differences in starch digestibility occurred in the lower digestive tract. Only 50.9 percent of the starch from the dry rolled ration entering the intestines was digested there, resulting in only 81.4 per cent total digestion of starch. For the micronized rations, over 90 per cent of the starch entering the intestinal tract was digested there. Thus, about 98 per cent of the ingested starch from the micronized rations was digested in the total digestive tract.

Discussion

The results of these two trials indicate that the total digestion of starch from high concentrate rations can be increased by steam flaking and micronizing. There were small differences in the amount of starch digested in the rumen. The greatest influence on starch digestion seemed

Table 3. Ruminal, Intestinal and Total Digestion of Starch in Trial 2

Item	Grain processing methods			
	Dry rolled	Micronized 32 lb/bu.	Micronized 25 lb/bu.	Micronized 18 lb/bu.
Feed intake, g/D.M./day	5516	5976	6156	6012
Starch intake g/day	3494	3778	3914	3746
Ruminal digestion of starch, g/day	2100	2297	2509	2544
Intestinal digestion of starch, g/day	744	1405	1338	1120
Starch in feces, g/day	650	76	67	82
Total digestion of starch, g/day	2844	3702	3847	3664
Ruminal digestion, % of total starch intake	60.1	60.8	64.1	67.9
Intestinal digestion, % of starch entering intestine	50.9[1]	95.4[2]	95.5[2]	92.9[2]
Total digestine, % of total starch intake	81.4[1]	98.0[2]	98.3[2]	97.8[2]

[1,2] Values on the same line with different superscripts are significantly different ($P < .05$).

to be the percentage of starch that was digested in the intestinal tract. In both trials the starch in the dry rolled milo ration had a lower intestinal digestion than any of the other rations. This would indicate that the processing of milo was altering the structural integrity of the starch granules in the milo kernel, allowing increased microbial and enzymatic digestion of the starch.

There were about 250 g and 580 g more starch digested per day from the heat treated milo rations than for the dry rolled milo rations in trials 1 and 2, respectively. This represents 0.52 and 1.20 megacalories of additional net energy available for gain from the heat and pressure treated milo rations from which one could expect an additional 0.31 and 0.70 pounds of daily gain from the same quantity of feed in trials 1 and 2, respectively. Therefore. the additional digested starch would provide considerable extra energy to the animal for production purposes.

Starch digestion for the dry rolled rations in trial 2 was lower than that in trial 1. These trials were conducted with two different sources and possibly different varieties of milo, apparently resulting in differences in digestibility.

Dry Heat Processing of Sorghum Grain For Finishing Beef Cattle

Don Croka and Donald G. Wagner

Story in Brief

Two methods of processing milo in high concentrate rations for finishing beef cattle were compared. The treatments investigated were 1) micronized milo and 2) dry rolled milo. Two feeding trials were conducted. Trial 1 was a 150 day feeding trial with steers and trial 2 an 84 day feeding experiment with heifers. In trial 1, average daily feed intakes were 16.6 and 18.4 lb. (90 percent D.M. basis) on the micronized and dry rolled milo treatments, respectively. In trial 2, the intakes were 17.8 and 19.6 lb. on the same treatments, respectively.

Average daily gains were 2.74 and 2.75 lb. on the micronized vs. dry rolled treatment in trial 1 and 2.34 and 2.40 lb. in trial 2. The pounds of feed required per pound of gain were 6.05 vs. 6.72 in trial 1 and 7.67 vs. 8.42 pounds in trial 2 for micronized and dry rolled treatments, respectively. The values for average daily feed intake, daily gain and pounds of feed per pound of gain were not significantly different ($P>.05$) between treatments in either trial, although feed per unit of gain in trial 1 and feed intake in trial 2 approached significance ($P<.10$).

Introduction

Grains are added to the rations of finishing cattle to increase digestible energy intake. Modern day finishing rations may contain as much as 80 percent grain. The grain may supply up to 90 percent of the usable energy of the ration. Any improvement in the efficiency of utilization of the grain will be reflected in reduced feed requirement and possibly improved gain. Processing imparts certain physical and chemical changes which increase nutrient digestibility. Until recent years, dry heat processing of sorghum grain has not been widely used. The purpose of these studies, therefore, was to investigate the use of dry heat treatment, micronization, for processing sorghum grain in finishing rations for feedlot cattle.

Materials and Methods

Two trials were conducted to compare micronized and dry rolled sorghum grain. In the first trial, 16 Charolais crossbred feeder steers averaging 684 pounds were selected. They were gradually adapted to a

90 percent concentrate ration during a three week preliminary period. After the preliminary period, the steers were randomly assigned to two treatments with four animals per pen and two pens per treatment. Self-feeders were used in this trial.

The second trial was conducted with thirty Angus X Hereford crossbred feeder heifers averaging 648 pounds. The heifers were adapted to a 90 percent concentrate ration during a three week preliminary period. Following the preliminary period, the heifers were randomly allotted to the two treatments with three animals per pen and five pens per treatment. The treatments used in the two trials were as follows:

1) Dry rolled milo
2) Micronized milo

In this trial the heifers were fed daily in quantities which permitted availability of feed until the next feeding.

The equipment used for micronizing the milo was a reciprocating steel table. The table was ½ inch thick, 46½ inches wide and 13 feet long activated by a ½-horsepower electric motor. Eight gas-fired infrared generators, rated at 50,000 BTU per hour each and suspended approximately 6 inches above the table, were used to heat the milo as it passed over the table. Before being metered onto the table, the milo was cleaned by using a Clipper cleaner, model 27, to assure an even flow free of foreign materials for efficient operation of the machine. The milo after being passed under the gas-fired generators then dropped directly through a 8½ X 30 inch roller mill with a roller spacing of .003 inch.

The dry rolled milo was cleaned and rolled through the same roller mill as the micronized milo.

The composition of the experimental rations are given in Table 1.

Table 1. Ration Composition[1]

Ingredient	Dry Rolled Milo	Micronized Milo
Milo	80.0	80.0
Cottonseed hulls	5.0	5.0
Alfalfa meal pellets	5.0	5.0
Molasses	4.0	4.0
Soybean meal	4.0	4.0
Urea	0.7	0.7
Salt	0.5	0.5
Dicalcium Phosphate	0.4	0.4
Calcium carbonate	0.4	0.4
Aurofac-50	225 gm	225 gm
Stilbestrol-2	600 gm	600 gm
Vitamin A (30,000 IU/gm)	200 gm	200 gm

[1] Formulated on a 90% D.M. basis.

The rations were all formulated to contain the composition indicated on a 90 percent D.M. basis. The experimental rations were formulated to contain 90 percent concentrate-10 percent roughage. At two separate times during each feeding trial, rumen samples were collected from each animal. The rumen fluid pH values were determined immediately, and a small amount was saved for VFA analyses.

Initial and final weights were taken full with a 4 percent pencil shrink. Intermediate full weights were recorded every 28 days for both trials. The feeding period lasted 150 days for trial 1 and 84 days for trial 2. At the termination of the feeding trials, carcass data was collected from each animal.

Results

The proximate analysis data for the milo used for both treatments are presented in Table 2. The average moisture content for the micronized milo was 9.7 percent compared to 12.7 percent for the dry rolled milo. The average density for the micronized milo was 25 lb. per bushel.

Trial 1

The feedlot performance data for the 150 day feeding period are shown in Table 3. The average daily feed intakes (90 percent D.M.) on the micronized and dry rolled treatments were 16.6 and 18.4 lb., respectively ($P > .05$). The average daily gains on the micronized and dry rolled treatments were 2.74 and 2.75 lb., respectively. ($P > .05$). The pounds of feed required per pound of gain for the micronized and dry rolled treatments were 6.05 and 6.72, respectively. The difference in feed requirement per unit of gain approached significance ($P < .10$). The carcass data for this trial are shown in Table 4. There were no significant differences ($P > .05$) between treatments for any of the carcass traits measured.

Rumen pH values on the micronized and dry rolled treatments were 5.5 and 5.7 for the first sampling and 5.5 and 5.5 for the second sampl-

Table 2. Promixate Analysis of Milo

Feed[1]	Dry Matter	Crude Protein[1,2]	Ash[1]	Ether Extract[1]	Total CHO[1,3]
Dry rolled	87.3	10.66	0.87	3.46	83.97
Micronized	90.3	11.42	1.68	2.93	84.03

[1] Values expressed on 100% D.M. basis.
[2] 6.25 X percent Nitrogen=percent crude protein.
[3] 100—(Sum of figures for crude protein, ash and ether extract).

Table 3. Feedlot Performance

	Dry Rolled	Micronized
Trial 1 (150 days)		
No. of animals	8	8
Initial weight, lb.	684	642
Final weight, lb.	1082	1082
Daily feed, lb.[1,2]	18.4	16.6
Daily gain, lb.[2]	2.75	2.74
Feed/lb. gain, lb.[1,2]	6.72[1]	6.05[2]
Trial 2 (84 days)		
No. of animals	15	15
Initial weight, lb.	638	658
Final weight, lb.	840	658
Daily feed, lb.[1,2]	19.6[1]	17.8[2]
Daily gain, lb.[2]	2.40	2.34
Feed/lb. gain, lb.[1,2]	8.40	7.67

[1] Expressed on a 90% D.M. basis.
[2] Values with different superscripts were significantly different at the .10 level of probability.

ing, respectively. These values did not differ significantly between treatments.

Trial 2

The feedlot performance data for the 84 day feeding period are presented in Table 3. Average daily feed intake (90 percent D.M) on the micronized and dry rolled treatments were 17.8 and 19.6 lb., respectively, ($P<.10$). The average daily gains were 2.34 and 2.40 lb., and the pounds of feed required per pound of gain were 7.67 and 8.42 (90 percent D.M.), respectively on the micronized and dry rolled milo treatments.

Carcass characteristics, percent cutability and dressing percentage are shown in Table 4. There were no significant differences ($P>.05$) observed between carcass traits.

Rumen fluid pH values obtained on the micronized and dry rolled treatments were 5.6 and 5.7 for the first sampling and 5.7 and 5.8 for the second sampling, respectively ($P>.05$).

Discussion

As indicated, the average daily gains were quite similar on the dry rolled and micronized milo treatments in both experiments, being 2.75 vs. 2.74 lb. in trial 1 and 2.40 vs. 2.34 in trial 2 on the dry rolled and micronized milo treatments, respectively. In general, feed intakes and gains were depressed on the micronized milo treatment early in the feeding period in both trials with adaptation and compensation occur-

Table 4. Slaughter and Carcass Information

	Dry Rolled	Micronized
Trial 1		
Dressing, %[1]	67.3	66.6
Carcass grade[2]	7.4	7.3
Ribeye area, sq. in.	14.92	13.97
Fat thickness, in.[3]	0.51	0.57
Marbling[4]	10.0	10.1
Cutability, %	51.61	51.10
Trial 2		
Dressing, %[1]	64.4	64.2
Carcass grade[2]	8.5	7.9
Ribeye area, sq. in.	10.99	11.09
Fat thickness, in.[3]	0.74	0.71
Marbling[4]	12.1	11.1
Cutability, %	48.90	49.43

[1] Calculated on basis of live shrunk weight and hot carcass weight.
[2] U.S.D.A. carcass grade converted to following numerical designations: high prime-15, average prime-14, low prime-13, high choice-12, average choice-11, low choice-10, high good-9, average good-8, low good-7.
[3] Average of three measurements determined on tracing at the 12th rib.
[4] Marbling scores: 1 to 30, 11=slight, 14—small, 17—modest.

ring thereafter. Possibly a higher level of roughage during this period would have been beneficial.

The average daily intake (90 percent D.M.) was 1.8 lb. lower on the micronized milo treatment in both trials 1 and 2. A lower feed intake with nearly the same rate of gain is generally accompanied by a lower feed requirement per unit of gain. In this respect, the micronized milo showed a trend to be more efficient than dry rolled milo requiring .67 and .75 lb. less feed per pound of gain in trials 1 and 2, respectively. These reductions in feed/unit of gain correspond to 11.1 and 9.8 percent improvements in feed efficiency (total ration) for the micronized milo over the dry rolled milo in trials 1 and 2, respectively.

Assuming that the improvements in feed utilization can be attributed to processing of the milo fraction of the ration (80 percent milo in each ration), the corresponding improvement would be 13.9 percent (11.1/80) and 12.2 percent (9.8/80) for the micronized grain in trials 1 and 2, respectively. The magnitude of such improvements would compare favorable with improvements obtained from some other methods of milo processing previously studied.

Reconstituted Wheat for Finishing Beef Cattle

Ryan Christiansen and Donald G. Wagner

Story in Brief

Wheat reconstituted and fed by two different methods was compared with dry rolled wheat (DRW) in 90 percent concentrate rations for finishing beef cattle.

Wheat was reconstituted in the whole kernel form to 30 percent moisture and stored for 21 days prior to feeding. The reconstituted wheat was then fed in either the whole form with no further processing (WRW) or rolled prior to feeding (WRRW). Thus, the treatments compared were DRW, WRW and WRRW. Wheat represented 70 per cent of the total ration on a D.M. basis.

During the 129 day feeding period, average daily feed intakes (90 percent D.M. basis) were 11.9, 16.5 and 12.8 lb. on the DRW, WRW and WRRW treatments, respectively. The heifers on the WRW consumed significantly ($P<.01$) more feed than those on the other treatments. The average daily gains were 1.67, 2.07 and 2.00 lb. and the pounds of feed per pound of gain 7.15, 7.99 and 6.42 on the DRW, WRW and WRRW treatments, respectively. The heifers on the DRW gained significantly slower ($P<.01$), and the heifers on the WRW required significantly ($P<.05$) more feed than those on the other treatments.

In brief, this study suggests that reconstituted wheat may be more palatable than dry rolled wheat producing greater feed intakes and gains and, therefore, somewhat better feed efficiency.

Introduction

Wheat is a major economic crop in Oklahoma. During the past few years wheat has been competitive in price with other grains for feedlot cattle. Much of the previous work done with high concentrate rations for finishing cattle involved corn or milo. Reconstitution has proven useful for significantly increasing the feeding value of milo when done under proper conditions. Research evaluating reconstituted wheat is limited. Two previous studies investigating reconstitution of wheat for feedlot cattle suggested less response than is normally obtained from reconstitution of milo.

The objective of this experiment, therefore, was to further evaluate and compare the use of reconstituted and dry rolled wheat for finishing cattle.

Materials and Methods

Forty eight uniform, choice Angus feeder heifers averaging 437 pounds were selected for this experiment. During the preliminary period, the animals were gradually adapted to a 90 percent concentrate ration.

After the preliminary period the heifers were randomly alloted to three treatments with four pens of four heifers each per treatment (16 animals per treatment).

The three treatments were as follows:

1) Dry rolled wheat (DRW)
2) Whole reconstituted wheat-fed whole (WRW)
3) Whole reconstituted wheat-fed rolled (WRRW)

The dry rolled wheat was processed by rolling the grain through a 12 V 18″ roller mill. The reconstituted wheat treatments were obtained by reconstituting wheat in the whole form to 30 percent moisture. The reconstituted grain was then stored in air tight, plastic bags for 21 days prior to feeding. Temperature during storage was a minimum of 70° F. The whole reconstituted wheat-fed whole (WRW) was fed in the whole form with no further processing prior to feeding. The whole reconstituted rolled wheat (WRRW) was rolled prior to feeding. The roller mill described previously was used.

Compositions of the experimental rations are presented in Table 1. All rations were formulated to contain the composition indicated on a D.M. basis. The rations were formulated to be approximately 90 percent concentrate rations containing 5.0 percent cottonseed hulls and 5.0 percent pelleted, alfalfa meal. Wheat represented 70.0 percent of the total ration on a D.M. basis. Dry rolled milo was included in each ration at a level of 14 percent on a D.M. basis. The non-grain components were combined in a premix and mixed with the wheat and dry rolled milo at the time of feeding. Diethylstilbestrol was fed at a level of 10 mg per

Table 1. Ration Composition

Ingredient	Wheat Rations[1] Percent
Wheat	70
Milo	14
Premix[2]	16

[1] Formulated on a dry matter basis.
[2] Contained cottonseed hulls, pelleted alfalfa meal, soybean meal, urea, dicalcium phosphate, calcium carbonate, salt, aureomycin, vitamin A and diethylstilbestrol.

head per day. Feed was prepared and fed daily in quantities adequate to permit availability of feed until the next feeding.

Rumen fluid samples were collected on all heifers during the feeding period for rumen pH and VFA determinations. Rumen fluid pH values were determined on the samples immediately upon sampling. The rumen samples were then processed and stored for VFA analyses.

Initial and final weights were taken full with a 4 percent shrink. The feeding period lasted 129 days. At the end of the trial, specific gravities were determined on each carcass to determine net energy values of the feed using the comparative slaughter technique.

Results and Discussion

The proximate analysis data for the wheat treatments are presented in Table 2. As indicated, the average moisture contents for the dry rolled wheat (DRW), whole reconstituted wheat-fed whole (WRW) and whole reconstituted wheat rolled (WRRW) were 10.7, 36.1 and 34.3 percent, respectively. Particle size and weights per bushel are given in Table 3.

Table 2. Proximate Analysis of Wheat

Feed	Dry Matter	Crude Protein[1]	Ash[1]	Ether[1] Extract[1]	Total CHO[1,2]
			%		
Dry rolled wheat (DRW)	89.3	12.5[3]	1.7	1.4	84.4
Whole recon. wheat (WRW)	63.9	12.7[3]	1.8	1.3	84.2
Whole recon. rolled wheat (WRRW)	65.7	12.5[3]	1.8	1.3	84.4
Milo	88.2	10.0[4]	1.0	2.6	86.4

[1] Values expressed on 100% D.M. basis.
[2] 100 — (Sum of crude protein, ash and ether extract.)
[3] 5.71 X percent Nitrogen=crude protein.
[4] 6.25 X percent Nitrogen=crude protein.

Table 3. Particle Size and Density of Processed Wheat

	4mm	2mm	1mm	500 micron	250 micron	125 micron	Through 125 micron	Wt. per Bu[1]
	% Retained						Through	lb.
DRW	0.8	36.9	40.4	11.8	5.0	2.4	2.7	38.2
WRW	12.1	86.8	0.8	0.2	0.1	0.0	0.0	35.5
WRRW	78.8	19.7	11.1	0.2	0.1	0.1	0.0	29.0

[1] Test weights reported on 90% D.M. basis.

Feedlot performance data for the 129 day feeding period are presented in Table 4. The average daily feed intakes (90 percent D.M. basis) were 11.9, 16.5 and 12.8 lb. on the DRW, WRW and WRRW treatments, respectively. The heifers on the WRW consumed significantly ($P<.01$) more feed than those on the DRW and WRRW treatments. The average daily gains were 1.67, 2.07, and 2.00 lb., on the DRW, WRW and WRRW treatments, respectively. The gain on the DRW ration was significantly ($P<.01$) lower than on the two moist grain treatments.

The significantly lower gains on the dry wheat were likely related to the somewhat lower intakes. Possibly increased dustiness of the dry wheat ration or a less desirable ration physical form produced a less palatable ration resulting in lowered intakes and gains. The feed efficiency (feed/unit gain) on the DRW, WRW and WRRW treatments were 7.15, 7.99 and 6.42 lb., respectively. The heifers fed the WRW treatment required significantly ($P<.05$) more feed per unit of gain than those receiving the whole reconstituted wheat rolled prior to feeding.

These results suggest that wheat must be processed or broken by some means prior to feeding. Although not significantly different, the trend for a somewhat lower feed requirement per unit of gain on the WRRW ration (6.42) compared to the dry rolled wheat ration (7.15) might be explained by the somewhat higher intakes and gains on the WRRW. A similar trend was also observed in previous studies. The heifers on the WRRW showed a 19.8 percent increase in gain and a 10.2 percent better feed efficiency over those on DRW. In making energy intake and gain projections for feedlot cattle, an improvement in gain of this magnitude can in itself account for this much difference in feed efficiency even on the same ration. In other words, greater feed intakes

Table 4. Feedlot Performance[1]

	Dry Rolled Wheat (DRW)	Whole Reconstituted Wheat	
		Fed Whole (WRW)	Fed Rolled (WRRW)
No. of heifers	16	16	16
Initial weight, lb.	428	449	438
Final weight, lb.	642	715	695
Daily Feed, lb.[3,4]	11.94^{4}	16.53^{3}	12.84^{4}
Daily Gain, lb.[3]	1.67^{3}	2.07^{4}	2.00^{4}
Feed/lb. Gain, lb.[2]	$7.15^{1,2}$	7.99^{1}	6.42^{2}

[1] 129 days.
[2] Values with different superscripts differ significantly ($P<.05$).
[3] Values with different superscripts differ significantly ($P<.01$).
[4] 90% D.M. basis.

and/or more rapid gains on the same ration usually result in an improvement in feed efficiency. This is due largely, but not exclusively, to dilution of the maintenance requirement, a high fixed cost in cattle feeding.

Perhaps reconstituted wheat is more palatable than dry wheat resulting in somewhat better intakes and gains with some consequent increase in feed efficiency. In most reconstituted milo feeding experiments, on the other hand, reconstituted milo has not produced an increase in daily gains over those obtained on dry rolled milo. Rather, daily feed intake is usually somewhat lower while maintaining the same rate of gain. Therefore, the lower feed intakes normally observed on reconstituted milo, while maintaining the same rate of gain, usually result in a better feed efficiency.

Net energy values for the grain are given in Table 5. No significant difference existed between treatments, although the net energy values tended to be lower on the WRW treatment compared to the other two treatments.

Rumen fluid pH values were 5.5, 6.4 and 5.5 on the DRW, WRW and WRRW treatments, respectively. The pH values on the WRW treatment were significantly ($P<.05$) higher than on the other two treatments.

As noted in Table 6, no significant differences existed among any of the carcass traits.

In brief this study suggests that reconstituted wheat may produce somewhat greater intakes and gains than dry rolled wheat, and therefore, somewhat better feed efficiency. Moreover, wheat requires some form of processing and cannot be efficiently fed in the whole form.

Table 5. Net Energy Values

	Dry Rolled Wheat (DRW)	Whole Reconstituted Wheat: Fed Whole (WRW)	Whole Reconstituted Wheat: Fed Rolled (WRRW)
	Mcal/cwt.		
NE_{m+g} of total ration	76.9	64.4	79.3
NE_{m+g} of grain	88.5	70.5	91.8
NE_m of grain[1]	99.9	76.4	107.9
NE_g of grain[1]	66.6	50.9	71.9

[1] Grain refers only to wheat.

Table 6. Slaughter and Carcass Information

	Dry Rolled Wheat (DRW)	Whole Reconstituted Wheat	
		Fed Whole (WRW)	Fed Rolled (WRRW)
Dressing, %[1]	60.4	62.0	61.5
Carcass grade[2]	10.12	9.75	10.06
Ribeye area, sq. in.	9.45	9.56	9.61
Fat thickness, in.[3]	.62	.75	.66
Marbling[4]	22.67	21.08	21.92
Cutability, %	49.46	48.17	48.84

[1] Calculated on basis of live shrunk weight and chilled carcass weight.
[2] U.S.D.A. carcass grade converted to following numerical designations: high prime-15, average prime-14, low prime-13, high choice-12, average choice-11, low choice-10, high good-9, average good-8, low good-7.
[3] Average of three measurements determined on tracing at the 12th rib.
[4] Marbling scores: 1 to 30, 11–slight, 14=small, 17–modest.

High Moisture Harvested Wheat and Wheat Head Chop for Finishing Cattle

Donald G. Wagner, Don Croka and Tom Martin

Story in Brief

High moisture harvested wheat stored by two different methods and high moisture harvested wheat head chop were compared with dry wheat for finishing cattle. The treatments compared were: 1) dry rolled wheat, 2) high moisture harvested wheat-stored in oxygen limiting silo, 3) high moisture harvested wheat-preserved with propionic acid in a wooden bin and 4) high moisture wheat head chop.

The high moisture wheat contained an average of 23.4 percent moisture and the head chop 28.0 percent moisture. The head chop contained 63.9 percent grain and 36.1 percent non-grain.

In cooperation with USDA Agricultural Research Service, Southern Region.
Appreciation is extended to Roger Johnson for assistance in statistical analysis of the data.

Treatment produced a significant ($P<.05$) effect on feed intake, daily gain, feed/unit gain and dressing percent. In general, the head chop treatment produced the highest feed intake, lowest gain, highest feed requirement/lb of gain and lowest dressing percent. Some differences were also noted among the other treatments.

When the feedlot performance data were combined for all cattle, the average daily feed intake (90 percent D.M.) was 19.6, 20.5, 20.2 and 23.0 lb; daily gain was 2.66, 2.81, 2.67 and 2.31 lb; and feed/lb of gain 7.38, 7.28, 7.56 and 9.94 lb on the dry rolled wheat, high moisture-silo preserved, high moisture-acid preserved and wheat head chop treatments, respectively.

Intrduction

Wheat represents a major economic crop in Oklahoma with production approaching 100 million bushels annually in normal crop years. This is nearly four times the quantity of milo raised in Oklahoma. During the past few harvest years (primarily 1969-72), wheat prices were depressed to where wheat was competitive with other grains as an energy source. In the past few months, (1973), wheat prices have moved up substantially. At the present price of approximately $2.50 per bushel, wheat would not, however, be competitive as a feed grain. Nevertheless, there have been periods in recent history when wheat was priced competively with feed grains, and this may be true again in the future.

High moisture harvesting has proven useful as a processing technique for significantly improving the feeding value of milo for feedlot cattle. Little or no research is available, however, concerning the feeding value of high moisture harvested wheat vs. dry wheat. The objective of this experiment, therefore, was to compare high moisture harvested wheat and high moisture harvested wheat head chop with dry wheat for finishing cattle.

Materials and Methods

Forty eight Angus and Hereford feeder heifers, equal numbers of each breed, averaging 695 lb. were selected for use in this trial. The heifers were gradually adapted to a high concentrate ration during a two week preliminary period.

Following the preliminary period, the heifers were blocked into two breeds (Angus and Hereford) and then randomly alloted within breed to four treatments with three heifers per pen and four pens per treatment (two pens of three heifers in each breed-total of 12 animals per treatment). The four treatments compared were:

1). Dry rolled wheat
2). High moisture harvested wheat-preserved in an oxygen limiting silo.
3). High moisture harvested wheat-preserved with propionic acid and stored in a wooden bin.
4). High moisture wheat head chop.

The high moisture harvested wheat head chop (treatment 4) was harvested June 2, 1972. The high moisture harvested wheat grain (treatments 2 and 3) was harvested on June 3 and 4, 1972. The wheat contained approximately 23-24 percent moisture at the time the head chop and high moisture grain were harvested.

The dry wheat grain was harvested several weeks later when the grain contained approximately 11 percent moisture. All grain was of the Triumph variety and harvested from the same field. The wheat head chop was harvested by using a self propelled field chopper equipped with an adjustable cutter head. The header was raised to cut the wheat at a height at which all of the heads could be harvested with a minimum of straw. The harvested head chop material was then processed through a hammermill containing a recutter as it was blown into an oxygen limiting silo for storage. The high moisture wheat grain was harvested with a self propelled combine. The high moisture wheat grain for treatment 2 was stored whole in an oxygen limiting silo. The high moisture grain for treatment 3 was treated with approximately 1.8 percent propionic acid as the moist grain was being augured into a conventional wooden bin for storage.

The dry wheat and the two high moisture wheat grains were rolled through an 18 X 24″ heavy duty roller mill prior to feeding. The wheat head chop received no additional processing after removal from the silo.

The compositions of the experimental rations are shown in Table 1. The rations were formulated to contain the composition indicated on a dry matter basis. Wheat made up 70 percent of the total ration on a D.M. basis in the dry rolled, high moisture-silo preserved and high moisture-acid preserved wheat treatments. The only variable in these three rations was the method of wheat harvesting and preservation. These three rations were formulated to be 90 percent concentrate rations. In the wheat head chop treatment, wheat head chop and supplement constituted the complete ration.

The milo included in the wheat rations was dry rolled. Feed was prepared and fed daily in quantities which permitted feed availability until the next feeding.

Initial and final weights were taken after an overnight shrink off feed and water. The feeding period lasted 72 days.

Table 1. Ration Composition (DM basis)

Ingredient	Dry rolled and high moisture wheat treatments (1,2,3)	Wheat head chop treatment
Wheat	70.0	---
Head Chop	---	95.0
Milo	15.0	---
Cottonseed hulls	5.0	---
Ground Alfalfa	5.0	---
Soybean meal	3.0	3.0
Urea	0.6	0.6
Salt	0.5	0.5
Dicalcium phosphate	0.4	0.4
Calcium carbonate	0.4	0.4
Aurofac-50	112 gm/ton	112 gm/ton
Stilbestrol-2	300 gm/ton	300 gm/ton
Vitamin A (30,000 IU/gm)	200 gm/ton	200 gm/ton

Results and Discussion

The proximate analysis data are presented in Table 2. As noted, the high moisture harvested wheat contained an average of 23.4 percent moisture and the wheat head chop 28.0 percent moisture. Moreover, the head chop contained an average of 63.9 percent grain and 36.1 percent straw and chaff.

Feedlot performance data are presented in Table 3. The data are presented separately in the table for each breed, Angus and Hereford. Due to inadequate numbers of pens, it was impossible to feed all of the heifers in the same barn. Therefore, all of the Angus heifers and one replicate (one pen per treatment) of Hereford heifers were fed in one barn at Ft. Reno; the second replicate of Hereford heifers was fed in a second barn at Ft. Reno. In the analysis of variance a highly significant ($P<.01$) barn effect was obtained.

Due to the error terms in some cases being of rather different magni-

Table 2. Proximate Analysis

Feed	Dry Matter	Crude[1,2] Protein	Ash[1]	Ether[1] Extract
Dry rolled wheat	88.3	12.86	1.76	1.30
HM wheat-silo	76.6	12.46	1.82	0.98
HM wheat-acid	76.6	11.92	1.95	1.20
Head chop	72.0	13.83	5.03	1.22

[1] Values expressed on 100% D.M. basis.
[2] 5.71 X % nitrogen = % crude protein.

Table 3. Composition of Wheat Crop (D.M. basis)

	Percent[1] of Total	Standard Error
Grain	63.9	0.48
Non-grain	36.1	0.48

[1] Grain to non-grain ratio was determined by cutting representative wheat head samples at the same height as the head chop and delineating the grain and non-grain portions by hand shelling and separation.

Table 4. Feedlot Performance

	Dry Rolled Wheat	H.M. Wheat Oxygen Limiting Silo	H.M. Wheat Acid Preserved	Wheat Head Chop
Angus				
No. of heifers	6	6	6	6
Initial wt., lb.	702	706	704	712
Final wt., lb.	894	921	901	886
Daily feed, lb.[1]	20.3	20.7	20.5	22.0
Daily gain, lb.[2]	2.67[3]	2.99[2]	2.82[2,3]	2.35[1]
Feed/lb. gain, lb.[1,2]	7.61[1,2]	6.94[2]	7.27[2]	9.38[1]
Hereford				
No. of heifers	6	6	6	6
Initial wt., lb.	678	683	691	682
Final wt., lb.	870	873	873	845
Daily feed, lb.[1,2]	18.8[2]	19.2[2]	18.3[2]	23.7[1]
Daily gain, lb.	2.66	2.64	2.52	2.27
Feed/lb gain, lb.[1,2]	7.15[2]	7.63[2]	7.84[1]	10.50[1]

[1] Expressed o 90% D.M. basis.
[2] Values without a common letter differ significantly ($P \leq .05$).

tude, it was not possible to pool the error terms for the two breeds when conducting the AOV for some of the feedlot and carcass parameters. Therefore, the feedlot and carcass data are presented by breed.

Treatment produced a significant ($P<.05$) effect on feed intake. The cattle on the wheat head chop treatment consumed the most feed with little difference among the other three wheat treatments.

Treatment also had a significant effect ($P<.05$) on daily gain. The Angus cattle gained significantly less ($P<.05$) on the wheat head chop than on the other three treatments. Although not significantly different the same trend was evident for the Herefords. Moreover, the Angus cattle gained significantly ($P<.05$) faster on the high moisture-silo preserved wheat than on the dry rolled wheat, with no difference among the two moist wheat treatments. The lower gains on the wheat head chop can likely be attributed to the high roughage content (34.3 percent) of the total ration compared to the 10 percent roughage level on the other three rations. Such a ration might be more desirable in growing cattle programs where a higher roughage level is more suitable. It would be difficult to produce a wheat head chop containing less roughage than that produced in this study.

Treatment produced a significant effect ($P<.05$) on the feed required per unit of gain. As anticipated, the highest feed requirement was on the head chop treatment. No significant difference ($P>.05$) existed, however, among the three wheat grain treatments.

If the feedlot performance data are combined for all cattle, the average daily feed intake would be 19.6, 20.5, 20.2 and 23.0 lb; daily gain 2.66, 2.81, 2.67 and 2.31 lb; and feed/lb of gain 7.38, 7.28, 7.56, and 9.94 lb on the dry rolled wheat, high moisture-silo preserved, high moisture-acid preserved and wheat head chop treatments, respectively.

The 9.94 lb of head chop required per pound of gain represents a very satisfactory feed conversion considering that only 60.8 percent of the total ration was wheat grain (95 percent head chop X 63.9 percent wheat in the head chop = 60.8 percent wheat in total ration). This would result in a grain requirement per pound of gain of 6.04 lb (9.94 X 60.8 percent). The other three wheat treatments contained 85 percent grain in the total ration (70 percent wheat + 15 percent milo). These

Table 5. Slaughter and Carcass Information

	Dry Rolled Wheat	H.M. Wheat Oxygen Limiting Silo	H.M. Wheat Acid Preserved	Wheat Head Chop
Angus				
Dressing, %[1,5]	60.85[1,2]	61.38[1,2]	63.33[2]	58.58[1]
Carcass Grade[2]	9.17	10.00	9.67	8.67
Ribeye Area, sq. in.	10.59	10.64	11.56	11.51
Fat Thickness, in.[3]	.70	.62	.68	.58
Marbling[4]	13.00	15.00	13.67	11.00
Cutability, %	48.65	48.98	48.88	50.54
Hereford				
Dressing, %[1]	60.00	60.33	60.58	58.60
Carcass Grade[2]	8.33	8.17	8.17	7.83
Ribeye Area, sq. in.	11.34	11.43	11.10	11.00
Fat Thickness, in.[3]	.54	.50	.50	.45
Marbling[4]	11.17	10.67	11.17	9.83
Cutability, %	50.41	51.06	50.52	51.45

[1] Calculated on basis of live shrunk weight and hot carcass weight.
[2] U.S.D.A. carcass grade converted to following numerical designations: high prime-15, average prime-14, low prime-13, high choice-12, average choice-11, low choice-10, high good-9, average good-8, low good-7.
[3] Average of three measurements determined on tracing at 12th rib.
[4] Marbling scores: 1 to 30, 11=slight, 14=small, 17=modest.
[5] Values without a common letter differ significantly ($P<.05$).

three treatments produced an average feed conversion of 7.40 lb. of feed per pound of gain. This would translate to 6.29 lb of grain (7.40 X 85 percent) per pound of gain. Although the head chop feed conversions may look high, in reality, they are quite acceptable considering the nature of the ration.

Carcass data are presented in Table 5. In general, the cattle on the wheat head chop showed a trend for a somewhat lower dressing percent and carcass grade compared to cattle on the other three treatments.

Animal Wastes as Protein Sources for Ruminants

R. R. Johnson, J. R. Kropp and M. McGeehon

Story in Brief

In a continuing effort to determine if animal waste products can conceivably be recycled as feed ingredients, beef feedlot wastes (FLW) and dehydrated (DPW) and fermented (FPW) poultry wastes were tested as sources of crude protein or nitrogen for ruminants. FLW was tested as 40 percent of a growing lamb ration. In contrast to previous findings, the FLW samples tested this year were not only very low in crude protein (<12 percent) but that protein was of low digestibility, 40 percent or lower. This study suggested that composting may decrease the protein value of beef feedlot wastes.

DPW (30 percent crude protein) and FPW (22 percent crude protein) were fed as 15 and 25 percent of a growing-finishing lamb ration. Both products were palatable at those levels. When compared to rations containing soybean meal as the source of protein, rations containing 15 percent DPW and FPW supported similar gains over a 90 day feeding period. At 25 percent DPW and FPW, performance was slightly lower. Organic matter digestibility was not changed by either 15 or 25 percent DPW or FPW. Estimates of digestibility for the crude protein in DPW

and FPW were 66-75 percent and 55-59 percent, respectively. Thus, although the protein in poultry wastes was not as digestible as common natural protein sources, it was sufficiently digestible to be of interest as a feed ingredient.

Introduction

Previous work has suggested that animal wastes may contain considerable portions of digestible nutrients. Recycling of the wastes through animals could conceivably reduce the load of waste material for ultimate disposal in addition to possibly providing an inexpensive nutrient source. In work reported in 1971 (Okla. Agr. Exp. Sta. M.P. 87) wastes from beef cattle feedlots were found to contain as much as 44 percent ash. The organic matter remaining, however, varied from 42 to 56 percent digestible. Furthermore, the high nitrogen content (15-20 percent crude protein equivalent) was 60-71 percent digestible. It was of further interest, therefore, to test animal wastes as a source of nitrogen for the ruminant animal.

Since most poultry are also raised in confinement, accumulation of their wastes also presents a disposal problem. Poultry excreta contains about 30 percent crude protein equivalent and so also could serve as a source of N for ruminants. In the present studies, the digestibility of poultry litter and its ability to support lamb growth were also studied.

Materials and Methods

Trial 1. Studies With Beef Feedlot Wastes

Beef cattle feedlot wastes were collected from two sources. The first (FLW-4) was from the accumulated mound at Texas County Feedlot, Guymon, Okla. This year, most of the mound had been removed and so only a small portion was left to sample. The second source (FLW-5) was from the Hitch Feedlot, Guymon, Okla., and represented a batch of material which had been taken from selected areas in one pen. This material had been composted, using a mixing process with a front end loader to aerate the pile. These materials varied between 45 and 50 percent ash but, in contrast to previous samples tested, were only about 12 percent crude protein equivalent.

A new depletion—repletion technique was used to study the value of the nitrogen contained in these samples. Twelve growing lambs were fed a protein (or nitrogen) deficient ration, ration 1 in Table 1, for 3 weeks to deplete their protein reserves. A digestibility and nitrogen balance trial was conducted during the last 7 days of this depletion period. Total feces and urine collection techniques were used. Following the

Table 1. Composition of Rations for Feedlot Waste-Protein Study

Ingredient	1 Depletion	2 Low Protein	3 High Protein	4 FLW-4	5 FLW-5
	% in Ration, 100% D.M. basis				
Cottonseed hulls	35.0	35.0	35.0	7.4	7.4
Molasses, dried	6.0	6.0	6.0	6.0	6.0
Corn starch	10.0	10.0	10.0	10.0	10.0
Ground corn	48.1	42.1	36.1	32.6	32.6
Dicalcium phosphate	0.4	0.3	0.1	0.2	0.2
Limestone	0.1	0.2	0.4	-	-
Salt	0.4	0.4	0.4	0.4	0.4
Soybean meal	-	6.0	12.0	3.4	3.4
FLW-4[1]	-	-	-	40.0	-
FLW-5[2]	-	-	-	-	40.0
	Chemical composition, % D.M. basis				
Ash	3.15	3.86	4.08	22.72	24.16
Organic matter	96.85	96.14	95.92	77.28	75.84
Cellulose	17.12	18.26	17.70	11.70	11.25
Crude protein	7.43	11.10	12.64	10.88	10.54

[1] Texas County Feedlot — samples taken from remains of accumulation pile — June, 1972.
[2] Hitch Feedlot — composted feedlot waste.

depletion phase, the lambs were allotted 3 per group to rations 2-5 shown in Table 1. Ration 3 was a positive control with soybean meal (SBM) supplied to satisfy NRC requirements for growing lambs. Ration 2 was a negative control with half the allowance of SBM as used in ration 3. In rations 4 and 5, FLW-4 and FLW-5 were substituted at the 40 percent level, primarily at the expense of cottonseed hulls.

The contribution of protein by the feedlot wastes was approximately equivalent to the SBM allowance in Ration 2 (see chemical composition in Table 1). This would allow for maximum efficiency of utilization of protein. The rations were designed to contain sufficient digestible energy for growth and nitrogen retention as long as the nitrogen source was a usable one. However, since the energy values of the FLW samples were unknown, the energy levels were probably not the same in all rations. Digestion and nitrogen retention trials were conducted during weeks 2 and 4 of the repletion phase. Methods of analysis for feed, feces and urine were routine.

Trial 2. Studies with Poultry Wastes

Samples of dehydrated poultry wastes (DPW) and fermented poultry wastes (FPW) were supplied by the Merry Lea Corporation, Kansas City, Missouri. DPW was poultry excreta collected without any litter and dehydrated. FPW was the same material which had been processed by a fermentation system and dried. The DPW averaged 30 percent crude protein and the FPW, 22 percent. Both materials were tested primarily as protein sources in lamb growing rations.

Forty eight lambs weighing approximately 46 lb. were randomly allotted to the 6 ration treatments illustrated in Table 2. All lambs were housed in individual pens and were provided feed and water free choice. All lambs were weighed every 15 days.

Twelve similar lambs were used to determine digestibility of these rations. The lambs were allotted two per block to a 6 x 6 latin square design in which the rotation allowed for all lambs to be exposed to all rations. Each rotation consisted of a one week adaptation period followed by a one week collection period. Feces and feed were analyzed by routine methods.

Results and Discussion

Trial 1. Feedlot Wastes

The results of the digestion and nitrogen balance trials with feedlot wastes are reported in Tables 3 and 4. Digestibility of dry matter was depressed by the inclusion of FLW in these rations but this would be expected based on their high ash content. The digestibility of organic matter was not decreased and actually appeared to be increased in the FLW-5 rations. Digestibilities were not changed appreciably in the SBM rations (medium and high protein controls).

Nitrogen digestibility was obviously increased by the addition of SBM to the rations (Table 4). It also appeared to increase as the re-

Table 2. Composition of Rations Containing Dehydrated Poultry Waste (DPW) and Fermented Poultry Waste (FPW).

	Composition, %, moisture free basis					
Ingredient	Pos. Control	15% DPW	25% DPW	15% FPW	25% FPW	Neg. Control
Cottonseed hulls	35.0	35.0	35.0	35.0	35.0	35.0
Molasses	5.0	5.0	5.0	5.0	5.0	5.0
Corn starch	10.0	10.0	10.0	10.0	10.0	10.0
Ground corn	34.8	27.4	22.2	24.2	17.2	44.0
Soybean meal	14.4	6.6	1.6	9.8	6.7	5.0
DPW	—	15.0	—	15.0	—	—
FPW	—	—	25.0	—	25.0	—
Salt	0.6	0.6	0.6	0.6	0.6	0.6
Limestone	0.2	0.2	0.2	—	—	0.2
Dicalcium phosphate		0.2	0.4	0.4	0.5	0.2
Vit. A	+	+	+	+	+	+
Vit. D	+	+	+	+	+	+

Table 3. Dry Matter Intake and Apparent Digestibilities of Dry Matter, Organic Matter and Cellulose when Rations Containing High Levels of FLW-4 and FLW-5 were Fed to Sheep.

	Period	D.M. Intake gm/day	Apparent digestibilities Dry matter	Organic matter	Cellulose
			%	%	%
Med. Protein control					
Digestibility on basal	1	648	67.6	64.3	30.7
Digestibility on test	2	898	63.7	64.0	29.4
ration	3	875	71.3	71.6	35.8
High protein control					
Digestibility on basal	1	756	66.4	66.4	35.9
Digestibility on test	2	914	65.4	65.7	20.2
ration	3	917	70.1	69.3	32.6
FLW-4 (TCF)					
Digestibility on basal	1	667	64.9	65.1	30.6
Digestibility on test	2	896	56.7	70.3	40.8
ration	3	867	57.2	64.9	40.4
FLW-5 (HF)					
Digestibility on basal	1	788	59.2	59.5	21.4
Digestibility on test	2	860	52.2	67.2	30.7
ration	3	864	55.8	70.4	42.0

Table 4. Parameters of N-Utilization When Feedlot Wastes Contribute Major Portions of the Dietary-N in Sheep Rations.

	Period	Nitrogen Intake	Nitrogen digestibility	Nitrogen balance
		gm/day	%	gm/day
Medium protein control				
Basal ration	1	7.69	43.4	1.83
Test ration	2	15.87	56.1	5.82
	3	15.54	63.0	6.32
High protein control				
Basal ration	1	8.98	38.6	2.04
Test ration	2	18.49	58.6	5.94
	3	18.55	64.9	6.06
FLW-4 (TCF)				
Basal ration	1	7.92	40.7	2.05
Test ration	2	15.61	38.7	3.36
	3	15.09	44.5	3.13
FLY-5 (HF)				
Basal ration	1	9.37	29.3	2.07
Test ration	2	14.17	36.2	1.98
	3	15.30	44.3	3.32

pletion trial progressed from period 2 to period 3. Nitrogen balance was increased markedly by SBM supplementation and to approximately the same degree by the two levels of SBM. Thus, the medium protein control was apparently supplying sufficient protein to satisfy requirements under these circumstances and the extra SBM in the high protein control was being provided in excess of requirements. Nitrogen digestibility was not increased over the basal ration by the addition of FLW-4 or FLW-5. This is in contrast to the high digestibilities noted in the previous years work. Since this years products were lower in total nitrogen, it would suggest that the digestible forms of nitrogen had been lost in the composting processes. As a result of the low nitrogen digestibility, nitrogen balance was improved only slightly if at all, even though the nitrogen content of these rations were equivalent to the medium protein control.

In conclusion, even though the organic matter of the feedlot wastes studied this year was fairly digestible, it appears the nitrogen was of low value ($\leqslant$40 percent digestible). Digestible nitrogen may be lost in composting operations.

Trial 2. Poultry Wastes

The growth performance of lambs fed the DPW and FPW rations is reported in Table 5. Performance has been reported for 30 day periods as well as the entire 90 day feeding period. Gains during the first 30 days were exceptionally good averaging 0.34 kg (0.75 lb) per day except for the lambs on the negative control which obviously grew more slowly. Substitution of DPW or FPW for SBM did not appear to be deleterious during this period except possibly for the 25 percent DPW group which appeared to gain less than the positive control. From the standpoint of protein requirement, this stage of growth is the most critical period.

Although consumption of feed increased in the second 30 day period, gains were extremely low. This could be accounted for by a period of extremely warm weather. During the last 30 days the gains increased somewhat and approached normal gains.

The animals on the positive control and 15 percent DPW or FPW appeared to gain faster overall (0-90 days) than those on 25 percent DPW or FPW rations. However, these differences were not statistically significant ($P > .05$). Some substitution of the corn in the ration was made by the DPW and FPW. Thus, performance figures could be confounded by a change in energy content since the energy value of DPW and FPW were not known.

The daily feed consumptions did not show any palatability problems with DPW or FPW at the levels used. Feed required per unit of gain appeared to be slightly higher for the DPW and FPW rations.

Digestibilities of the same rations are shown in Table 6. Dry matter

Table 5. **Growth Performance of Lambs Fed Rations Containing Dehydrated Poultry Waste (DPW) or Fermented Poultry Waste (FPW).**

Component	Positive Control	15% DPW	25% DPW	15% FPW	25% FPW	Negative Control
Number of lambs	8	8	8	8	8	8
Initial weight, kg	20.6	20.5	20.6	20.6	20.7	20.7
Avg. daily gain, kg						
0-30 days	0.341[1-2]	0.350[1]	0.288[1-2]	0.390[1]	0.345[1]	0.240[2]
30-60 days	0.167	0.131	0.104	0.160	0.104	0.139
60-90 days	0.218	0.235	0.220	0.109	0.182	0.183
0-90 days[3]	0.238	0.239	0.204	0.220	0.210	0.188
Average daily feed cons., kg						
0-30 days	1.15	1.24	1.15	1.27	1.22	0.95
30-60 days	1.60	1.85	1.64	1.71	1.91	1.40
60-90 days	1.43	1.60	1.43	1.37	1.54	1.44
0-90 days	1.39	1.56	1.41	1.45	1.56	1.26
Feed efficiency, kg feed/kg gain						
0-30 days	3.40[2]	3.63[1-2]	4.25[1]	3.32[2]	3.59[1-2]	3.90[1-2]
30-60 days	9.90	17.03	22.55	10.69	19.57	11.37
60-90 days	7.49	7.46	6.73	8.90	9.72	8.20
0-90 days[3]	5.89	6.66	7.10	7.15	7.50	6.81

[1-2] Means with different superscripts are significantly different ($P < .01$).
[3] Means for 0-90 days were not significantly different ($P > .05$).

Table 6. **Apparent Digestibilities of Rations Containing Dehydrated Poultry Waste (DPW) and Fermented Poultry Waste (FPW).**

Component	Positive Control	15% DPW	25% DPW	15% FPW	25% FPW	Negative Control
Dry matter	64.6	63.8	60.4	63.0	61.9	58.7
Organic matter	65.6	65.8	63.9	65.5	65.4	60.0
Cellulose	27.5	43.6	45.9	43.0	49.5	28.4
Crude protein	58.0	54.2	56.0	52.3	50.7	44.2

digestibility decreased as the content of DPW and FPW increased in the ration. Since organic matter digestibility did not decrease, however, the depression in dry matter digestibility would be assumed to be due to the high proportion of insoluble ash in the DPW and FPW. It would appear then that the organic matter in the poultry waste products was about 65 percent digestible. Since cellulose digestibility in the DPW and FPW rations was higher, the cellulose in the DPW and FPW products themselves must be quite digestible. The source of this cellulose is unknown.

Digestibility of crude protein decreased only slightly (non-significant) by the addition of DPW but somewhat more with FPW. Using standard values for digestibility of the protein in the other ration ingredients, it was possible to estimate the protein digestibility for the test ingredient. These estimates were 66-75 percent for DPW protein and 55-59 percent for FPW protein. Thus, the fermentation process used in producing FPW decreased both the protein content and digestibility.

The Effect of a Variable Protein-Energy Ratio on Feedlot Performance and Carcass Traits of Steer Calves

Donald R. Gill and R. R. Frahm

Story in Brief

Steer calves averaging 205 days in age were weaned and placed on two fairly high energy feedlot rations. One ration was formulated using the National Research Council recommendation of 8.1 percent digestible protein and the other ration was reduced from a high of 11.14 percent digestible protein to 8.00 percent digestible protein in steps throughout the course of the feeding period.

Feedlot gains on the variable protein ration were higher with the largest differences evident during the first third of the feeding period. These data suggest that the NRC recommendation of 8.1 percent digestible protein may not be adequate for young cattle on moderate to high energy rations. Feed efficiency, rate of gain, and cost of grain were all improved when comparing the variable protein ration to the ration formulated to the NRC recommendation.

Introduction

Protein requirements of feedlot cattle are mainly dependent on the weight and rate of gain of the cattle and on the energy density of the ration. Since feedlot cattle vary in weight and rate of gain through the feeding period, the protein requirements for maximum performance may also vary. Thus, perhaps total feedlot performance can be enhanced by supplying protein at a level necessary to support maximum growth and weight gain at each stage of the feeding period, rather than an average protein level over the entire feeding period.

This experiment trial was conducted to test a ration designed to supply digestible protein at a rate determined by the estimated level of gain of the cattle at 100 lb. weight increments throughout the feeding period. Estimated gain was calculated using probable feed intakes and calculating gain using the net energy equations of Lofgreen and Garrett 1968. The ration digestible protein for the variable protein ration was determined using the equation: total digestible protein, lbs.=0.0040 $W^{0.75}$ + G X 0.40. In this formula, W is equal to the animal weight in pounds and G is the calculated average daily gain in pounds. This ration was compared to a ration formulated using the 1970 NRC recommendation of 8.1 percent digestible protein.

Materials and Methods

Experimental rations were formulated using the O.S.U. developed linear programming technique. Net Energy gain was held to a constant 57 megcalories Net Energy Gain per hundred weight on all rations. Table 1 shows the composition of the rations and Table 2 shows the composition of the pelleted supplement. The ration compositions are presented in Table 3. All ration compositions are expressed on a zero moisture basis. Care was taken to adjust the zero moisture basis formulas

Table 1. Ration Composition in Percent (Zero Moisture Basis)

Ingredient	NRC	Ration 500	Ration 600	Ration 700	Ration 800	Ration 900
Alfalfa hay	6.52	6.57	6.56	6.55	6.55	6.54
Cottonseed hulls	3.79	3.82	3.81	3.80	3.80	3.80
Fat (Beef tallow)	3.20	3.32	3.29	3.25	3.23	3.21
Rolled Milo	77.18	69.77	72.13	74.62	76.06	77.40
Molasses	4.08	4.07	4.06	4.05	4.05	4.05
Soybean Meal, 44%	.23	7.45	5.15	2.73	1.31	----
Supplement	5.00	5.00	5.00	5.00	5.00	5.00
Total	100.0	100.0	100.0	100.0	100.0	100.0

to the as fed moisture content of the feed commodities to accurately control ration composition. Dry ground milo was the main energy source used in the experimental ration and based on previous net energy trials, it was assigned an energy value of 90 meg. cals. NEm and 60 meg. cals. NEg. This would compare to values of 97 meg. cals. NEm and 64 meg. cals. NEg for the steam flaked milos used in many commercial feedlots.

On the variable protein levels, cattle were started on the 500 level ration and were changed t[illegible]vel when the animals weighed an estimated 600 lbs., to the 700 level at 700 lbs. etc. When the variable protein lot reached the 900 level, no further reduction of protein was made to simplify feed mixing procedure. The steers on the NRC ration Lot was held on a constant ration with 8.1 percent digestible protein

Table 2. Pelleted Supplement Composition (Zero Moisture Basis)

Ingredient	Percent Composition
Ground Milo	48.665
Urea 45% Nitrogen	13.000
Salt	6.000
Calcium Carbonate	13.000
Stilbesterol 2 gram/lb.	.700
Vitamin A 30,000 IU/gram	.210
Aureomycin 10 gram/lb.	1.425
Soybean meal 44%	17.000
Total	100.00

Table 3. Calculated Composition of Experimental Rations (Zero Moisture Basis)

Component	NRC	Ration 500	Ration 600	Ration 700	Ration 800	Ration 900
Energy, maint. meg-cal/cwt.	88.97	88.98	88.98	88.97	88.97	88.97
Energy, gain meg-cal/cwt.	57.00	57.00	57.00	57.00	57.00	57.00
Crude Protein (total)	11.76	14.88	13.89	12.84	12.22	11.66
Protein from Urea	1.83	1.83	1.83	1.83	1.83	1.83
Digestible Protein	8.10	11.14	10.17	9.15	8.55	8.00
Ether Extract	6.28	6.25	6.25	6.27	6.28	6.29
Crude fiber	6.43	7.22	6.96	6.70	6.54	6.40
Potassium	.69	.82	.78	.73	.71	.68
Calcium	.46	.46	.46	.46	.46	.46
Phosphorus	.34	.34	.34	.34	.34	.34
Total	100.0	100.0	100.0	100.0	100.0	100.0

throughout the trial. Stilbestrol was removed from the supplement for the required 7 day withdrawal before slaughter.

The 69 choice angus steers initially alloted to the experiment were the progeny of eight sires involved in a progeny testing program as a part of the cattle breeding project. In order to maintain valid progeny test comparisons between sires, half of each sire group was randomly alloted to each treatment group. The steers were weaned at an average of 205 days at the Lake Carl Blackwell range where they had been maintained with their dams without creep. At weaning, they were transported to the Fort Reno Livestock Research Station, where they were placed immediately on feed in two adjoining pens that opened to the South from a feeding barn. One steer died during the experiment and only data from the 68 steers completing the experiment were analyzed.

The actual weaning weights obtained at the Blackwell Range were used as the initial test weights even though the average shrink to the feeding site in previous years averaged about nine percent. The cattle were trucked to the feeding site and placed immediately on feed in the two feed pens in order to avoid some of the problems which frequently result when cattle are held off feed and water for extended periods of time. The test rations were diluted with a decreasing amount of cotton hulls such that they were on full feed on the experimental ration in about ten days. Rations were fed using self feeders.

Results and Discussion

Both pens of steers started on feed without any digestive or health problems. As indicated by the 43 and 79 day weights, the lot on the variable protein ration gained significantly faster during the first part of the test. The feedlot performance and carcass data are presented in Table 4. Steers were slaughtered at 191 and 216 days on test in order to slaughter the steers as they reached the choice grade. An equal number of the fattest steers were selected from each of the two lots for the 191 day kill and the remainder were killed at 216 days. Statistical analysis of the data showed no interaction between the kill date and the experimental treatments, even though the cattle selected for the first kill gained much more rapidly than did the remainder. Data were pooled over the two slaughter periods for presentation on the results.

The steers on the variable protein ration significantly outgained the steers on the NRC constant protein ration by 0.17 lbs. per day ($P<.05$). Most of this increased rate of gain occurred during the first half of the feeding period as evidenced by 21 and 37 lbs. more gain by the variable protein steers during the first 43 and 79 days on test, respectively. Although the daily feed consumptions were similar for the two rations,

Table 4. Feedlot Performance and Carcass Data

Trait	Feedlot Ration: NRC	Feedlot Ration: Variable Protein	Pooled Std. Deviation
Number of steers	35	33	
Feedlot Data:			
Initial weight, lbs.	487	490	47.1
First 43 day gain, lbs.	92	113*	30.7
First 79 day gain, lbs.	214	251*	34.4
Average daily gain, lbs.	2.77	2.94*	0.323
Final weight,[1] lbs.	1014	1050	84.4
Avg. daily feed,[2] lbs.	19.5	19.9	
Feed conversion,[2] lbs. feed/lb. gain	7.05	6.79	
Feed cost per lb. of gain (cents)	17.12	16.88	
Carcass Data:			
Carcass weight, lbs.	640	655	54.3
Dressing percent, %	63.1	62.4	
Kidney, heart and pelvic fat, %	3.2	3.3*	0.46
Carcass grade[3]	10.5	10.5	3.57
Ribeye area, sq. in.	12.2	11.9	1.03
Ribeye area/cwt., carcass wt.	1.91	1.81*	0.193
Marbling score[4]	5.60	5.67	1.02
Fat thickness, in.	0.91	1.07**	0.227
Cutability (%)[5]	49.2	48.0**	1.72

[1] Final weight shrunk 4%.
[2] Expressed on an as fed basis.
[3] USDA carcass grades converted to the following numberical designations: high choice 12; ave. choice 11; low choice 10; high good 9.
[4] Marbling score equivalents: modest=6; small=5; slight=4.
[5] Estimated percentage boneless retail cuts from round loin rib and chuck.
*Means significantly different at the 0.05 probability level.
**Means significantly different at the 0.01 probability level.

the variable protein steers gained sufficiently more rapidly to reduce the amount of feed required per lb. of gain by 0.26 lbs. The steers on the variable protein ration had 0.16 in. more fat cover (P<.01) and 0.1 percent more kidney, heart and pelvic fat (P<.01). In spite of this increased external fat, there was no difference in the marbling score for the two groups of steers. Thus, there was not any difference in carcass grade. The increased fat cover did, however, result in a 1.2 percent reduction in estimated cutability (P<.01) for the variable protein ration steers.

Steers fed the variable protein ration consumed more soybean than did the steers on the NRC ration. (See Table 1) In total, they consumed an average of 76 lbs. per head more of soybean meal than did the NRC lot. At the time this experiment was conducted, soybean meal cost $4.50 per Cwt. and ground milo ready to feed cost $2.25 per Cwt. thus the substitution of soybean meal for milo in these rations cost $1.71 per head for the duration of the test.

Feed only costs including shrinkage and processing were $17.12 per Cwt. on the NRC ration and $16.88 per Cwt. on the variable protein ration[1]. Cattle on the variable protein ration made more rapid gains, had a slightly better feed conversion ration 6.79 vs. 7.05 on an as fed basis and a lower cost than the steers on the NRC ration. Because the gain defferences were largest early in the test, and, because the variable protein cattle were fatter at slaughter time they might have exhibited even larger advantage in terms of rate and efficiency of gain had they been killed at an equal slaughter weight with the NRC cattle.

All rations contained 0.65 percent feed grade urea. Rations 500, 600, and 700, with soybean meal may have failed to have had sufficient urea fermentation potential for good utilization of the urea nitrogen based on the formula proposed by Burroughs et al 1972. Additional investigation will be required to resolve the question of this possibility.

The results of the trial suggest that additional protein above the NRC recommendation may be desirable for young light weight cattle during the first part of the feeding period when using high energy rations.

[1] Ration cost per hundred (dry)

NRC -	$2.43
500	2.60
600	2.55
700	2.49
800	2.45
900	2.42

References

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

R. A. Dean, L. E. Walters, D. F. Stephens, J. W. Holloway and Robert Totusek

Story in Brief

The feedlot performance and carcass characteristics of calves sired by Angus bulls and out of Hereford, Hereford x Holstein, and Holstein cows which had been on different levels of winter supplement were compared.

Most apparent differences were those due to breed of dam. Calves out of Hereford cows tended to gain the fastest and those out of Holstein cows the slowest. Calves out of Holstein cows were least efficient. Calves out of Holstein cows required the longest feeding period and were heaviest at slaughter, followed by calves out of the crossbreds.

Calves out of Holstein cows had an advantage in dressing percent, marbling, carcass grade, and tenderness.

Introduction

The cow-calf operator trying to obtain the highest possible return per dollar invested is interested in increasing the weaning weight of his calves. Research has shown a strong positive relationship between level of milk production in beef cows and weaning weight of their calves. Selection of heifer calves higher in weaning weights will result in higher milk production, but a faster method of increasing milk production in the cow herd is to infuse dairy breeding. The resulting increase in milk production should increase weaning weight, but in order to fully evaluate this practice, the feedlot performance and carcass characteristics of calves with a percentage of dairy breeding should be determined.

The primary purpose of this experiment was to compare the feedlot performances and carcass characteristics of calves out of Hereford, Hereford x Holstein crossbred and Holstein females.

Experimental Procedure

Calves used in this study were sired by Angus bulls and out of Hereford, Hereford x Holstein and Holstein females calving for the first time. These calves were dropped from mid-November, 1970 through

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In cooperation with USDA Agricultural Research Service, Southern Region.

February, 1971. At calving their dams within each breed were assigned to one of two (Hereford and Hereford x Holstein) or three (Holstein) levels of winter supplementation designated as Moderate, High or Very High. Daily post-calving amounts of a 30 percent protein supplement consisted of approximately 2.5, 5.5 and 7.7 lb. for Moderate, High and Very High treatments, respectively. The experimental design is illustrated in the heading of Table 1.

The calves were placed in the feedlot at weaning which was at 240 ± 7 days. Their weaning weight, taken after a 12-hour shrink, was used as the initial feedlot weight. The calves were fed an 80 percent concentrate ration containing 65 percent milo, 10 percent wheat, 10 percent alfalfa, 7.5 percent soybean meal, 1.0 percent urea, 5.0 percent molasses and 1.0 percent salt and minerals. Stilbestrol and Vitamin A were also added at recommended levels. Calves were vaccinated upon entry into the feedlot for blackleg, PI3 and IBR. Calves were group fed, by sex and by dams' breed and supplement level.

Cattle were slaughtered as each steer or heifer reached an anticipated grade of choice based on apparent fatness. Slaughter weight was based on an overnight 12-hour shrink. Animals were slaughtered at a federally inspected commercial packing plant. After slaughter, all carcasses were chilled for 24 hours after which time a USDA grader estimated quality grade, marbling score, maturity, conformation score and kidney, heart and pelvic fat. A tracing was made at the 12th-13th rib separation on each carcass to determine rib-eye area and backfat thickness. Cutability was calculated using the Murphy cutability prediction equation.

Shear values were determined on two-inch rib steaks removed at the 12th rib. The steaks were cooked to an internal temperature of 150° F. After 24 hours of chilling, three cores were taken from each steak and each core was subjected to three shear tests.

Results and Discussion

A summary of feedlot performance and carcass characteristics of calves grouped according to breed and level of winter supplement of their dams is shown in Table 1 for steers and Table 2 for heifers. With the small number of calves per treatment and lack of consistent patterns, it is difficult to make definite conclusions concerning possible effects of level of winter supplement of the dams of calves on their feedlot performance and carcass merit.

Steers and heifers are compared according to breed of dam in Table 3. Calves from the crossbred and Holstein dams required a longer feeding period (an average of 17 and 46 days) and were heavier at slaughter (approximately 100 and 200 lb.) than calves out of Hereford cows. Breed differences in rate of gain were largest among steers; steer calves out of

Table 1. Feedlot Performance and Carcass Characteristics of Steer Calves (All Sired by Angus Bulls)

Item	Breed of Dam and Supplement Level						
	Hereford		Hereford x Holstein		Holstein		
	Moderate	High	Moderate	High	Moderate	High	Very High
No. of head	5	7	6	6	4	7	9
Initial wt., lb.	507	518	556	535	608	635	641
Slaughter wt., lb.	938	906	1018	1039	1146	1121	1181
Days fed	127	128	149	169	180	180	203
Daily gain, lb.	3.37	3.07	3.09	3.00	3.03	2.73	2.70
Feed/lb. gain, lb.	6.82	7.34	7.20	7.42	8.06	8.60	8.68
Carcass wt., lb.	555	545	616	630	703	683	732
Dressing percent	59.2	60.2	60.5	60.6	61.3	60.9	62.0
Ribeye, sq. in.	11.7	10.5	11.7	11.6	11.0	12.1	12.8
Backfat thickness, in.	0.75	0.87	0.78	1.00	0.90	0.69	0.75
Cutability, %	49.09	47.86	48.25	47.08	45.76	48.87	48.1
Marbling score[1]	12.6	12.7	12.3	14.1	15.0	16.0	17.9
Carcass grade[2]	9.2	9.4	8.8	10.0	10.0	10.0	11.0
Shear value[3]	19.8	18.6	19.3	18.4	16.1	18.0	16.5

[1] Higher value indicates more marbling.
[2] 8=Average Good, 9=High Good, 10=Low Choice, 11=Average Choice.
[3] Low value indicates greater tenderness.

Table 2. Feedlot Performance and Carcass Characteristics of Heifer Calves (All Sired by Angus Bulls)

	Breed of Dam and Supplement Level						
	Hereford		Hereford x Holstein		Holstein		
Item	Moderate	High	Moderate	High	Moderate	High	Very High
No. of head	7	6	7	7	7	7	3
Initial wt., lb.	483	456	516	554	569	579	568
Slaughter wt., lb.	861	803	936	930	1039	1036	993
Days fed	152	155	162	149	179	202	180
Daily gain, lb.	2.66	2.33	2.57	2.57	2.65	2.33	2.28
Feed/lb. gain, lb.	8.21	8.13	7.20	7.42	9.45	9.61	9.44
Carcass wt., lb.	526	496	580	571	655	650	627
Dressing percent	61.1	61.8	62.0	61.4	63.0	62.7	63.1
Ribeye, sq. in.	11.1	10.0	11.4	10.9	12.0	11.8	12.3
Backfat thickness, in.	.80	.95	.96	1.00	.89	.71	.91
Cutability, %	48.1	47.2	46.9	46.4	47.1	47.5	47.5
Marbling score[1]	14.5	13.7	13.4	15.1	17.4	15.0	15.7
Carcass grade[2]	9.9	9.7	9.6	10.1	11.0	10.0	10.3
Shear value[3]	17.8	18.2	20.5	18.0	16.0	18.5	17.6

[1] Higher value indicates more marbling.
[2] 8=Average Good, 9=High Good, 10=Low Choice, 11=Average Choice.
[3] Low value indicates greater tenderness.

Table 3. Feedlot Performance and Carcass Characteristics of Steer and Heifer Calves by Breed of Dam (All sired by Angus Bulls)

	Breed of Dam					
	Hereford		Hereford x Holstein		Holstein	
Item	Steers	Heifers	Steers	Heifers	Steers	Heifers
No. of head	12	13	12	14	17	17
Initial wt., lb.	513	467	546	535	628	572
Slaughter wt., lb.	922	832	1029	933	1139	1023
Days fed	128	153	159	156	188	187
Daily gain, lb.	3.22	2.50	3.05	2.57	2.82	2.42
Feed/lb. gain, lb.	7.08	8.17	7.31	7.97	8.45	9.50
Carcass wt., lb.	550	511	623	575	706	644
Dressing percent	59.7	61.5	60.6	61.7	61.4	63.3
Ribeye, sq. in.	11.1	10.6	11.7	11.2	12.0	12.0
Backfat thickness, in.	.81	.88	.89	.98	.78	.83
Cutability, %	48.5	47.7	47.7	46.7	47.6	47.4
Marbling score[1]	12.7	14.1	13.2	14.3	16.3	16.0
Carcass grade[2]	9.3	9.8	9.4	10.4	10.3	10.4
Shear value[3]	19.2	18.0	18.8	19.3	16.9	17.3

[1] Higher value indicates more marbling.
[2] 8=Average Good, 9=High Good, 10=Low Choice, 11=Average Choice.
[3] Low value indicates greater tenderness.

Hereford cows gained the fastest, followed by calves out of crossbred cows and Holstein cows. Heifers out of Holstein cows also gained the slowest. Feed efficiency was poorest for calves of both sexes out of Holstein cows.

Calves out of Holstein cows had an advantage in dressing percent, marbling score, carcass grade and tenderness, with slightly less fat cover than calves out of Hereford and crossbred cows.

An economic analysis of feeding costs and returns is presented in Table 4, 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	41.00	36.00
Hereford x Holstein	39.00	34.00
Holstein	37.00	32.00
Value of carcasses (per cwt.)		
Choice	54.00	52.50
Good	51.00	49.50

Feed was valued at $45.00 per ton and yardage and interest are charged at the rate of $0.20 per day.

The return above initial value of the calves, feed, yardage and interest was calculated. On this basis, calves out of the Holstein cows were the most profitable, followed by those out of the crossbred cows. The

Table 4. Economic Analysis (Average for Steers and Heifers)

	Breed of Dam		
Item	Hereford	Hereford x Holstein	Holstein
Carcass value, $	274.60	311.01	355.11
Feedlot costs, $			
Initial value of calves	189.58	197.33	207.70
Feed cost	67.83	76.64	98.44
Yardage and interest	28.20	31.50	37.47
Total costs	285.61	305.47	343.61
Return above initial value, feed, yardage and interest, $	—11.01	5.54	11.94
Value of carcass less cost of feed, yardage and interest, $	178.58	202.87	219.67
Value of calf for feeding, %	36.37	37.53	36.60

breed differences in returns were primarily due to the differences in initial value assumed for the calves.

Another type of calculation was made. Feed, yardage and interest costs were substracted from the value of the carcass, and the resulting return was divided by the initial weight of the calves to provide an estimate of the value of the calves for feeding. On this basis, calves from cows of the three breeds were relatively close in value, \$37.53, \$36.90 and \$36.37 per cwt. for calves from crossbreds, Holsteins and Herefords, respectively.

Meat and Carcass Evaluation

The Relationship Between Backfat and Loin Eye Area Measurements and the Weight of the Lean Cuts in Swine Carcasses

I. T. Omtvedt, L. E. Walters, John Mabry, R. K. Johnson and R. F. Queener

Story in Brief

This study included the data from 190 slaughter barrows from the Ft. Reno swine breeding herd evaluated at the O.S.U. Live Animal Evaluating Center and Meat Laboratory in 1971 fall and 1972 spring. Barrows were removed from test as they weighed 220 lbs. and were evaluated for backfat thickness using the leanmeter probe and the scanogram. A Scanogram estimate of loin eye area at the tenth rib was also obtained. The whole body scintillation counter was used to obtain estimated pounds of lean cuts from the K^{40} count on the live pig. These estimates of fatness, loin area and lean cut yield were then compared to the actual carcass cutout data on the pigs.

The correlations between the various measurements of backfat thickness ranged from 0.57 to 0.69 with the scanogram backfat estimate and carcass backfat determination having the closest relationships. This would be expected since the probe backfat thickness readings were taken 1½ inches off midline while measurements for the other two methods were taken at the midline. In the first season, scanogram estimates of loin area were recalculated whenever marked differences were observed between the scanogram estimate and the carcass loin area. This insured a high correlation between the two estimates. In the second season, the two determinations of loin area were obtained independently and the correlation between the two methods was 0.49 compared to 0.80 for the first season. The average correlation between the actual weight of the lean cuts and the K^{40} estimate of lean cut yield was 0.56.

In order for a measurement to be considered a reliable predictor of lean yield, it should account for at least 90 percent of the variation in

yield. In these data, the variation in weight of lean cuts accounted for by the various measurements of backfat thickness, loin eye area or K^{40} count ranged from 13 to 41 percent. Using both backfat thickness and loin area measurements increased the predictability to a limited extent, but it was not sufficient to conclude that measures of loin area and backfat thickness on the live pig are adequate predictors of weight of lean cuts.

Introduction

Most carcass traits in swine are moderately to highly heritable. This means that one should attempt to measure the trait directly on potential breeding stock whenever possible rather than relying on the performance of relatives as an indicator of the animal's merit. For example, if a trait has a heritability of 50 percent, it takes about 100 full sibs to be equivalent to one record on the animal himself. Because performance data on relatives are not as accurate and the fact that carcass data are expensive to obtain, swine breeders are very much interested in obtaining measurements on the live animal that are reliable predictors of carcass merit.

Recently, ultrasonic estimates of backfat thickness and loin eye area have been widely used by the swine industry as indicators of carcass desirability. This study was initiated to determine the relative value of these estimates in predicting lean cut yield in swine.

Materials and Methods

A total of 190 market barrows of Duroc, Hampshire and Yorkshire breeding herds were used in this study. All pigs were self fed a 16 percent crude protein ration in confinement from weaning to 220 lbs. and were removed from test on a weekly basis as they reached 220 lbs. The data included approximately 10 purebred barrows from each of the three breeds and about 20 barrows from each two-breed cross combination (10 from each reciprocal combination). The pigs were randomly selected for evaluation each season as they completed test. The distribution by season and breed-type is shown in Table 1.

Probe backfat measurements were taken 1½ inches off the midline behind the shoulder, at the last rib and in front of the ham; and the average depth was used. The pigs were trucked to Stillwater and evaluated the next day at the O.S.U. Live Animal Evaluation Center after being held off feed and water over night. The Ithaco Scanogram Model 721 was used to obtain ultrasonic measurements of backfat thickness and loin area. This instrument combines the Branson Sonoray Animal

Table 1. Distribution of Barrows Evaluated by Year and Breeding

	Season Evaluated	
	1971	1972
Durocs	12	10
Hampshire	12	11
Yorkshire	12	10
Duroc-Hamp Crosses[1]	20	20
Duroc-York Crosses[1]	20	21
Hamp-York Crosses[1]	20	22
Total	96	94

[1] The reciprocal combinations are combined.

Tester, Model 12 with a Polaroid camera. The transducer (positioned in a guide which fits the curvature of the animal's body) and the Polaroid camera are linked together by means of a mechanically synchronized drive which moves the transducer along the animal's body at the same speed the camera is scanning the oscilloscope of the Sonoray.

When high frequency sound waves strike tissues differing in density, part of the high frequency energy passes into the second medium while the remaining energy is reflected back to the Sonoray and appears on the oscilloscope in the form of an "echo." The mechanism allows these "echoes" to be recorded on a Polaroid print from which interpretations for backfat thickness and loin eye area can be made. 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 estimate was made at the tenth rib.

Each animal was evaluated in the O.S.U. K^{40} whole body scintillation counter. Five 1-minute counts were taken with background counts taken before and after the pig was confined to the chamber. The net K^{40} count was then used to predict pounds of lean cuts using the question:

$$43.876 + 0.00676\ (^{40}K\ \text{Count})$$

This equation was calculated from data on similar pigs evaluated and slaughtered in 1970 fall and reported in the 1972 Animal Sciences and Industry Research Report MP-87. This equation accounted for 55 percent of the variation in lean cut weight for the pigs evaluated in 1970.

Carcass backfat thickness was measured on each side of the carcass at the first rib, last rib, and the last lumbar vertebra; and the average depth was used. Carcass loin eye was measured between the tenth and eleventh rib before the outside fat was removed. Essentially all the outside fat was removed from the ham, loin, and shoulder prior to obtaining the total weight for these cuts.

The means and standard deviations for the traits evaluated each season are presented in Table 2. The 94 barrows evaluated in 1972 tended to have less backfat thickness, larger loin area, and heavier lean cut weights than the 96 barrows slaughtered the previous season, but the variability was similar for both seasons.

Results

The results obtained are presented in Tables 3, 4 and 5.

Relationship Between Different Measurements for the Same Trait

The pooled within breed group correlations for each season and the overall average are given in Table 3. Although the magnitude of the correlations between different backfat determination methods were similar, the scanogram and carcass backfat readings were in closest agreement. This would be expected since both were measured at the midline while the probe reading was taken 1½ inches off midline. The correlation between the scanogram estimate of loin eye area and the carcass loin eye measurement was considerably higher in 1971 than in 1972. Part of this discrepency was due to the fact that some scanogram pictures were recalculated the first year when a marked difference between the two estimates was obtained. This forced a high correlation between the two estimates. In order to more accurately reflect the true situation that occurs when evaluating breeding stock where the actual loin eye area is not known, all scanogram areas were obtained in 1972 without knowledge regarding the actual carcass loin eye area.

Table 2. Means and Standard Deviations by Year for Traits Evaluated

	1971		1972	
	Mean	Standard Deviation	Mean	Standard Deviation
Backfat Thickness, in.				
Probe	1.37	0.17	1.25	0.17
Scanogram	1.23	0.16	1.13	0.15
Carcass	1.24	0.15	1.19	0.14
Loin Eye Area, sq. in.	5.16	0.53	5.32	0.52
Carcass	4.84	0.57	4.92	0.67
Total Lean Cuts, lbs.				
K^{40} count estimate	82.73	4.37	81.24	4.03
Carcass cutout	85.03	4.62	88.54	4.66

Table 3. Pooled Within Breed Correlations Between Different Measurements for the Same Trait

	1971	1972	Overall Average
Backfat Thickness Measurements:			
Carcass and scanogram	.65	.69	.67
Carcass and probe	.46	.61	.53
Scanogram and probe	.57	.63	.60
Loin Eye Area Measurements:			
Carcass and scanogram	.80	.49	.65
Total Weight of Lean Cuts:			
Carcass and K^{40} count	.62	.51	.56

The K^{40} prediction equation accounted for 38 percent of the variation in lean cut weight in 1971 and only 26 percent of the variation in 1972. Although the correlation between K^{40} count and total lean cuts was rather low, it should be pointed out that a high relationship was not expected. Previous work at O.S.U. has shown that K^{40} count is a more accurate predictor of the total amount of separable lean and the total amount of fat-free lean in the carcass than it is of pounds of lean cuts.

Relationship Between Lean Cut Yield and Measurements of Backfat and Loin Area

The pooled within breed correlations for each season and the average are given in Table 4. In general, the correlations involving measures of fatness and loin area with lean cut weight were similar for both seasons with a tendency for the correlations to be somewhat lower in the second season. However, the only marked discrepancy between years was noted for the correlations involving scanogram backfat thickness with

Table 4. Pooled Within Breed Correlations Between Lean Cut Weight and Measurements of Backfat and Loin Area

	Carcass Lean Cut Weights			K^{40} Predicted Lean Cut Weights		
	1971	1972	Overall Average	1971	1972	Overall Average
Probe backfat	—.48	—.40	—.44	—.36	—.37	—.36
Scanogram backfat	—.64	—.36	—.50	—.38	—.42	—.40
Carcass backfat	—.40	—.36	—.38	—.37	—.40	—.38
Scanogram loin area	.47	.32	.39	.33	.14	.23
Carcass loin area	.59	.56	.57	.50	.41	.45

lean cuts. It accounted for 41 percent of the variation in lean cut weight in 1971 and for only 13 percent of the variation in 1972. Carcass loin eye area consistently accounted for more of the variation in lean cut yield than did the other measurements.

Relative Effectiveness of Various Measurements in Predicting Lean Cut Weight

The percentage of the variation in lean cut weight accounted for by the various measures of fatness and loin area for the two seasons is given in Table 5. The various measurements evaluated in this study accounted for more of the variation in weight of lean cuts in 1971 than in 1972. In 1971, scanogram backfat and loin area combined accounted for 45.4 percent of the variation, but they accounted for only 19.3 percent of the variation in 1972.

Over both years, carcass backfat and loin area combined accounted for the highest proportion of the variation in lean cut weight. However, in order for a measurement to be considered a reliable predictor of lean yield, it is assumed that the measurement should account for at least 90 percent of the variation in lean cut yield. Based on these data, it is concluded that none of the measurements evaluated should be considered adequate predictors. New techniques and measurements are needed in order to adequately evaluate carcass merit on the live pig.

Table 5. Effectiveness of Various Measurements in Predicting Total Weight of Lean Cuts in the Carcass

Measurement Used to Predict	% of Variation in Lean Cuts Accounted For In.	
	1971	1972
Probe backfat thickness	23.0	16.3
Scanogram backfat thickness	40.4	13.3
Carcass backfat thickness	15.9	13.0
Scanogram loin eye area	21.7	10.2
Carcass loin eye area	34.5	30.9
K^{40} prediction equation	38.4	25.8
Scanogram backfat & loin area combined	45.4	19.3
Carcass backfat & loin area combined	42.7	34.7

Evaluation of the K^{40} Technique for the Determination of Fat-Free Lean in Ground Meat

T. R. Carr, L. E. Walters, R. D. Morrison and R. F. Queener

Story in Brief

This research was initiated to investigate the feasibility of using the K^{40} technique as an acceptable method for determining fat-free lean and from this value to estimate ether-extractable materials (mostly fat) in ground meat. The development of whole-body counters such as the O.S.U. whole-body counter, has made it possible to measure gamma radiation arising from the element potassium and thus to predict muscling in meat animals in a non-destructible manner.

There are two properties of potassium that make its quantitative measurement in animals and their tissues useful and practical. First, potassium appears to be relatively independent of body fat and therefore, makes up a relatively constant proportion of the fat-free body when considered within species and age groups. Secondly, the measurement of potassium is possible because a small but constant amount of potassium is radioactive.

A new K^{40} counter configuration (involving eight detectors arranged in a stack) was used in counting ground meat samples. Forty pound lean samples containing five different levels of added fat and lean were prepared and K^{40} counted on two consecutive days in July, 1972. The ratios of lean to fat in the five ground meat samples were representative of the variation found in lean trimmings customarily used in the sausage industry. Net K^{40} count and ether-extract analyses were conducted on the five different samples and fat-free lean values were calculated by difference. The data were analyzed statistically and a prediction equation and correlations were developed.

Introduction

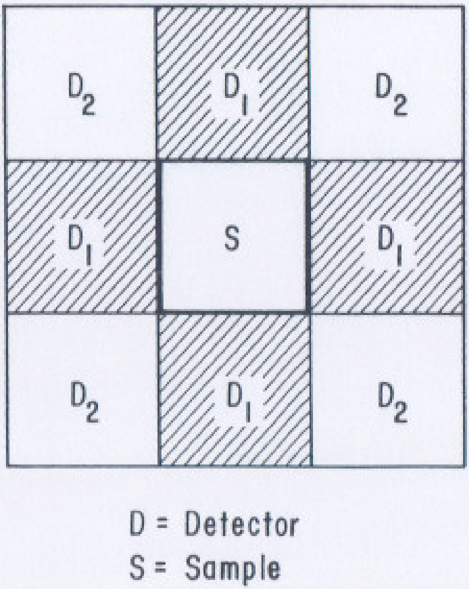
Effective quality control procedures for the meat processing industry require that such methods be rapid and accurate. The sausage industry, in particular, is in need of such methodology for the control of fat concentrations in blended and seasoned products. Currently, laboratory methods in use for the determination of fat (ether-extract) in these products is time consuming and the results of the analyses are often not available until after the product has reached marketing channels. Therefore, in order to produce sausages and other processed meats that have no more fat than is allowed under provisions of a contract or appropri ate label, many processors aim for a fat concentration lower than the permitted level, thus severly reducing profits by manufacturing a leaner product.

The search for a rapid, accurate method for determining fat-free ean (and from this to determine fat concentration by difference) has rompted the investigation into the feasibility of applying the K^{40} tech- ique for this purpose. Such a technique has shown considerable promise n the estimation of fat-free lean in live animals and it would appear nat these principles may well be applicable to animal tissue used in ie meat processing industry as well.

Materials and Methods

Eight detectors from the O.S.U. whole-body counter were removed m the cattle counting instrument and positioned in a "stack" con- uration in such a manner as to create a tunnel in which ground beef nples were placed for K^{40} counting, Figure 1.

The D_1 detectors were used to monitor gamma radiation arising n muscle potassium in the samples while the D_2 detectors were used ly for support. The ground beef samples (1, 2,3, 4, 5) were prepared dding different levels of fat to different amounts of lean obtained n a common source of very lean beef, Table 1.



. Schematic of tunnel K^{40} counting configuration

Table 1. Composition of Ground Beef Samp

	Lbs. Lean Ground Beef	Lbs. Added Fat
Sample 1	30.0	10.0
Sample 2	32.5	7.5
Sample 3	35.0	5.0
Sample 4	37.5	2.5
Sample 5	40.0	0.0

The lean was obtained from bull chucks and rounds. It was closel trimmed to remove as much subcutaneous and intermuscular fat as po sible, then ground through a 3/8 inch plate and thoroughly mixed in a mechanical mixer. The source of added fat was beef kidney fat, whic was also ground through a 3/8 inch plate. The components of each sa ple were carefully weighed, thoroughly mixed, re-ground through a inch plate, re-mixed and placed in polyethylene bags for K^{40} counting. the ground meat samples were prepared, 100 gram samples for chemi analysis were taken from each of the five 40 pound samples. Ether-extr analyses using a modified Goldfisch method were conducted in triplic on each of the five 100 gram samples. After the 40 pound samples w prepared, they were transported to the O.S.U. Live Animal Evaluat Center and counted on two consecutive days in July, 1972.

The order for K^{40} counting of the five samples was completely domized. Five two-minute counts were taken on each sample with two-minute background counts taken before and after each sample cc Each of the five two-minute counts per sample was randomized counting order on the first day. The same procedure with a new domization order was repeated on the following day in order th estimate of the day-to-day repeatability of the K^{40} counter could b termined. Samples were stored in refrigeration when not being co After the two days of K^{40} counting, the samples were returned t Meat Laboratory where each sample was thoroughly mixed and sa again for ether-extract analysis. All ether-extract analyses were d triplicate.

Results and Discussion

Five forty pound ground meat samples each containing d amounts of lean were counted in the O.S.U. whole-body K^{40} cou two successive days in July, 1972. Chemical analyses for ether were conducted on the five ground meat samples and fat-free l determined by difference. The K^{40} net count data and the ethe data were analyzed statistically. In the analysis, the logarithm of net K^{40} count data was used to express the magnitude of this variable.

The coefficient of variation,

$$C.V. = \frac{\sqrt{\text{Error Mean Square}}}{\text{Overall Mean}} \times 100$$

was used as an estimate of the repeatability of K^{40} net count during the experiment. The coefficient of variation for the log net K^{40} count was found to be 2.8 percent.

By comparison, it should be noted that some methods involving analytical apparatus with coefficients of variation up to 6 to 8 percent are considered to be within useful operating limits. The coefficient of variation for the ether-extract procedure was found to be 0.8 percent (this is presented as an estimate of technician error in running the ether-extract analysis).

The plotted data in Figure 2 presents the relationship between log net K^{40} count and fat-free lean in the sample. An approximate 95 percent confidence interval was made on a regression line for predicting log net K^{40} count from fat-free lean. The following equation was developed:

$$\hat{Y} = 3.088 + 0.0150X$$

where $\hat{Y}$ represents the estimate of log net K^{40} count and X represents the average pounds of fat-free lean obtained from twelve ether-extract values from each forty pound ground meat sample. In order to use this equation, one obtains the logarithm net K^{40} count on ten two-minute K^{40} net counts (5 on one day and 5 on the next). The average of these ten logarithms is substituted in the equation for $\hat{Y}$ and the equation is solved for X (which is average pounds of fat-free lean in the forty pound sample):

$$X = \frac{\text{Logarithm Net } K^{40} \text{ Count} - 3.008}{0.0150}$$

The approximate confidence bounds can be found from Figure 2. For example, (see dotted lines in Figure 2), if the average log net K^{40} count for a forty pound sample is 3.62, the estimate for the amount of fat-free lean would be 35.6 pounds with a range from 34.9 to 36.3 pounds. These values were obtained by using the confidence bounds on the regression line. The correlation between log net K^{40} count and pounds of lean in the samples was 0.99 and the correlation between log net K^{40} count and pounds of fat-free lean was 0.96.

It should be emphasized that this prediction equation was developed for forty pound samples of meat which contained between 30 and 39

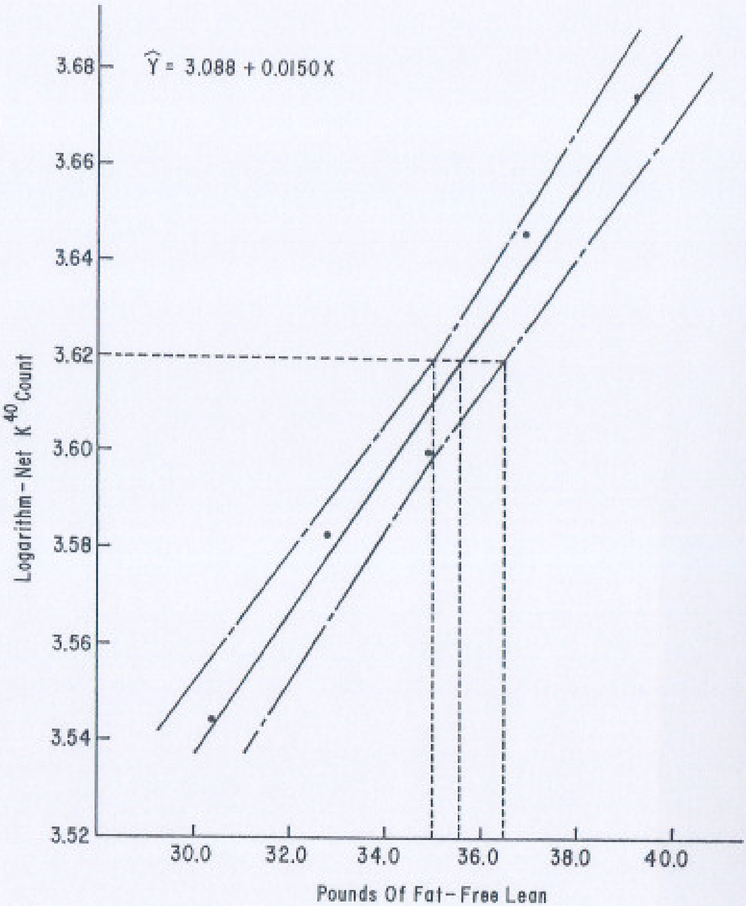


Figure 2. Logarithm-Net K^{40} count as related to pounds of fat-free lean

pounds of fat-free lean. The equation is applicable only to the counting configuration and conditions described above and used in these procedures conducted in the O.S.U. whole-body counter.

Meat Quality Changes Resulting from Pre-rigor Muscle Boning of the Bovine Carcass

R. L. Henrickson and Stanley Falk

Story in Brief

Twelve choice and good grade animals were slaughtered, observed, fabricated into individual muscles and muscle systems, for detailed study. Muscle pH was used to follow the level of change in rigor mortis. The conditioning periods studied were 3, 5, and 7 hours. The ultimate pH was reached by the 5 hour period at 16°C. A major advantage in hot processing is the preservation of weight. The hot processing method reflected a loss of only .90 while the conventional chill method lost 2.71 percent.

Introduction

The purpose of this research is to design and evaluate a method of processing and fabricating the beef carcass such that bone and excess fat are removed prior to refrigeration. Thus the elimination of unnecessary cooling of inedible entities will be provided while yielding meat items of comparable, if not improved quality, to conventional processing methods. Therefore the processor would benefit from shorter refrigeration time, increased yields of boneless, fat-free meats, which could be stored in less space thus providing maximization of the refrigerated space. The consumer would benefit by receiving a more sanitary, higher quality product.

Procedure

Forty Angus steers were utilized in the course of the study. The animals were of the choice grade and will be slaughtered after reaching a weight of approximately 1,000 lbs. Each animal was assigned to a 3, 5, or 7 hour holding period for the hot side. The designation of hot or cold sides was randomized. The cold side was moved directly from the slaughter floor into a Chill cooler (1.1°C).

Hot & Cold Treatments

HOT—Immediately after conventional slaughter and Federal Inspection the "hot" side was placed in a 16°C holding room. The side was held suspended from a rail via a pulley and hook placed through the tendon of Achilles. Thermocouples were then inserted into 4 test muscles, Biceps femoris (BF), Longissimus dorsi (LD), Semimembranosus (SM), Semitendinosus (ST). Each thermocouple was in turn connected to a Honeywell recording potentiometer. At the expiration of a particular holding period the side was weighed and fabricated into a streamlined hindquarter.

This fabrication consisted of the removal of the chuck at the fifth thoracic vertebra and the flank and plate as done in the commercial trade. After the streamlined hindquarter was weighed, dissection of the muscles was initiated, while it hung from the rail in a 16°C holding area. First, excess fat was stripped from the muscle so that only the epimysium remained on the muscle surface. The muscle excision progressed in the following order: Tensor fascia latae, Sartorius, Semimembranosus, Semitendinosus, Biceps femoris, Quadricpes complex, psocis, Gluteus complex, and finally the Longissimus dorsi. The remaining small muscles were placed into lean trim. The long axis of each dissected muscle was measured immediately upon dissection. Then the bone, fat, lean trim and excised muscles were each put into a separate moisture and oxygen impermeable Cry-O-Vac bag. Finally, the components were removed to a 1.1 C cooler for 48 hours (same cooler as the hanging side).

Cold — Immediately after slaughter and Federal inspection, the "cold side" was placed into a 1.1 C cooler for 48 hours. After the expiration of this specified time the "cold" side was fabricated into a streamlined hindquarter, following the procedure as previously described for the "hot" side.

pH: Measurements of pH were taken at 1-5 hours post-mortem and then again at 24 and 48 hours from the Psoas major. The pH was used as a guideline to estimate the end point of glycolysis or rigor mortis in both hot and cold sides. The procedure used was to place 10 g. of finely minced muscle into 50 ml of distilled water., A combination calomol-hydrogen electrode was placed directly into the resulting sample.

Yield: At the expiration of 43 hours and completion of the "cold" side dissection all components were weighed for the determination of yield.

Calculations were made as follows:

$$\text{Cold side} = \frac{\text{cold shrunk side wt} \times 100}{\text{Hot side wt.}} = \%\text{ loss}$$

$$\text{Hot side} = \frac{\text{sum of streamlined hindquarter comp.}}{\text{Initial streamlined hindquarter wt.}} \times 100 = \%\text{ loss}$$

The sections of Psoas major which were removed for pH determination were weighed and then "figured back into" the yield determination.

Shortening of Muscles: After each muscle was dissected from the "hot" side, the long axis was carefully measured using a flexible rule. At the end of the 48 hours chill period, each muscle was removed from the bag and again re-measured. A comparison of the length (degree of shortening) was made within the initial determination and with the muscles measured for the cold side.

Microbial Determination: The lean trim from both "hot" and "cold" sides was separately ground in a washed and sanitized grinder. Each sample was ground twice, once through a coarse plate and a second time through a fine plate. Then separate 25 g aliquots were weighed and placed into 225 ml of sterile distilled water in a sterile Waring Blender. The sample was then blended for 1 minute at high speed. This constituted a 1:10 dilution. Next 10 mls of the 1:10 dilution were placed in 90 ml of sterile distilled water to constitute a 1:100 dilution. A 1:1,000 and a 1:100,000 dilution were then prepared in a similar manner using 1 ml in 99 ml water. Plates were allowed to incubate at 34°C for 3 days and a second set of plates at 15°C for 7 days.

Chemical, Histological, Color, Organoleptic, Shelf Life, Tenderness Studies: From the muscles of the streamlined hindquarter, four were chosen for the indicated determinations: Biceps femoris (BF), Longissimus dorsi (LD), Semimembranosus (SM), Semitendinosus (ST), The cutting of each muscle into steaks was accomplished in the following order:

Current Results

pH: The pH as shown in Table 1 gives no indication of any drastic variation between sides held at 16°C or those held at 1.1°C for either the 3, 5, or 7 hour holding periods. It should be noted that the ultimate pH was reached at approximately 5 hours, post-mortem. This fact may influence the muscles excised at 3 hours post-mortem since this gives an indication that ATP was not at a low enough level to allow rigor mortis to be complete. Therefore, some shortening of these muscles may occur, resulting in meat that is less tender than muscles excised at 5 or 7 hours PM as compared to the "cold" control. These judgments will be verified upon the completion of the tenderness, taste panel, and histological examinations.

Yield Data (% Loss): The yield data this far collected is most promising as shown in Table II. Average percent loss for the hot sides was 1.18, 0.76, and 0.76 percent for the 3, 5, and 7 hour holding periods. On the other hand the loss of moisture for the control on conventionally processed sides was considerably more averaging 2.71 percent for the 12 sides. Therefore, the commercial advantage of "hot" processing becomes most important when one considers the monitary gain a 1-2 percent in-

Table 1. The Change in pH of Beef Muscle as Influenced by the Method of Processing

	Hours PM													
	1		2		3		4		5		24		48	
Animal No.	pH Hot	pH Cold	pH Hot	pH Cold	pH Hot	pH Cold	pH Hot	pH Cold	pH Hot	pH Cold	pH Hot	pH Cold	pH Hot	pH Cold
1112-3	5.73	6.07	5.57	6.12	---	---	5.46	5.68	5.46	5.82	5.47	5.50	5.51	5.47
1113-3	5.92	5.72	5.83	5.61	5.71	5.51	5.46	5.48	5.46	5.49	5.48	5.49	5.55	5.52
1120-3	5.60	5.47	5.35	5.46	5.35	5.44	---	---	5.35	5.38	5.38	5.44	5.38	5.44
0-3	5.98	6.05	5.93	6.05	5.78	5.94	5.56	5.94	5.41	5.93	5.46	5.48	5.32	5.21
X-3	5.81	5.83	5.67	5.81	5.61	5.63	5.49	5.70	5.42	5.66	5.45	5.48	5.44	5.41
55-5	6.20	5.85	6.07	5.61	6.08	5.86	6.12	5.93	5.86	5.84	5.53	5.47	5.42	5.41
100-5	5.75	6.02	5.49	5.67	5.42	5.50	5.45	5.57	5.47	5.44	5.47	5.45	5.43	5.45
1129-5	5.79	5.69	5.82	5.57	5.61	5.33	5.33	5.29	5.28	5.27	5.29	5.35	5.34	5.41
1144-5	6.07	6.13	5.93	6.01	5.96	5.86	5.88	5.90	5.71	5.63	5.30	5.36	5.26	5.25
X-5	5.95	5.92	5.83	5.72	5.77	5.64	5.70	5.67	5.58	5.54	5.40	5.41	5.36	5.38
1143-7	S	S	5.59	5.57	5.45	5.44	5.43	5.44	5.41	5.42	5.38	5.40	5.48	5.39
1116-7	5.98	5.57	5.70	5.53	5.57	5.47	5.39	5.39	5.39	5.39	5.50	5.50	5.50	5.51
1140-7	6.24	6.29	6.01	6.17	5.84	6.04	5.54	5.78	5.48	5.96	5.52	5.54	5.54	5.50
1126-7	6.02	6.03	5.85	5.99	5.67	5.88	5.42	5.62	5.43	5.43	5.49	5.45	5.49	5.50
X-7	6.08	5.96	5.79	5.82	5.63	5.71	5.44	5.56	5.43	5.55	5.47	5.47	5.50	5.48

X = Mean

Table 2. **The Weight Loss in Beef as Influenced by the Method of Processing**

An. #	Live Wt. (lbs)	Hot Side Wt. (lbs)	Cold Side Wt. (lbs)	Dr. %	Loss Hot (%)	Loss Cold (%)
3 hrs.						
1112-3	1080	334.5	334	62	1.92	2.69
1113-3	1036	338	325	64	0.70	3.80
1120-3	1090	343	334	62.1	1.05	2.10
0-3	1126	342.5	343	60.8	1.07	2.04
5 hrs.						
Mean	1083	339.5	334	62.2	1.18	2.66
55-5	1040	317	315	60.7	0.41	2.86
100-5	890	280.5	280.5	63	1.00	2.92
1129-5	1210	387	394	64.5	0.66	3.05
1144-5	1068	327	328	61.3	0.93	2.96
7 hrs.						
Mean	1052	327.8	329.4	62.4	0.76	2.95
1143-7	960	281	293	59.8	0.24	2.32
1116-7	1035	312.5	323.5	61.5	0.81	2.23
1140-7	1095	344.5	346.5	63	1.22	2.74
1126-7	1184	357	360	60.5	0.78	2.78
Mean	1068	323.7	330.7	61.2	0.76	2.53

crease in yield will offer the processor. As an operator became increasingly efficient, the loss would be further reduced. Theoretically a loss of less than 0.5 percent should be afforded by proper and efficient hot boning operations.

Grades and Grading: The twelve animals utilized to-date graded Choice and Good. General appearance of the hot muscle would indicate a similar grade as was placed on the cold carcass. Emphasis is now being given to the epimysial connective tissue layer as a feasible aid to visual grading. Fat streaking on the muscle surface along with general muscle appearance are also being considered. New mechanical tools (Rotating Dull Knife Tenderometer, Nip Tenderometer and Rapid Fat Testers) are being studied. Techniques for rapid color Measurement are also being investigated.

Changes in Bovine Muscle Tissue and Whole Body Potassium From Birth to Weaning Age

J. D. Gresham, J. J. Guenther, J. R. Escoubas and L. E. Walters

Story in Brief

Eight Angus and eight Charolais calves were used to study changes in muscle tissue and whole body potassium, in calves of different growth rates, during their pre-weaning life phase. Results showed that as the calves matured, muscle tissue potassium increased while whole body potassium decreased in concentration. In comparing the two breeds it was noted that the Angus calves had a higher content of muscle tissue potassium at Periods 1, 2 and 3 pre-weaning, but the Charolais calves were higher at the 4th test period. The Angus calves showed a net increase of 8.03 percent in muscle tissue potassium during the test, whereas the Charolais calves displayed a 35.98 percent net increase. Assuming muscle tissue potassium to be an indicator of "chemical maturity", results suggest that the Angus calves matured much earlier in life than did the Charolais.

Conversely, the Charolais calves were higher in whole body potassium at Periods 1, 2 and 3 and lower at Period 4 pre-weaning, than the Angus. It would appear that whole body potassium content, determined by ^{40}K count, is influenced by animal scale and surface area and that if ^{40}K count is to be used to estimate fat-free lean in live cattle, the ^{40}K count could be adjusted for animal scale and body mass.

Introduction

Although several research articles have been published in the past showing changes in various cation concentrations in muscle tissue with chronological age, these works have been accomplished on species other than the bovine. For instance Dickerson (1960) reported an increase in the concentration of muscle tissue potassium in fowl pectoral muscle with increasing age. Dickerson and Widdowson (1960) showed an increase in muscle tissue potassium of piglets at 6 weeks of age versus newborn pigs. However, Martin *et al.* (1968) reported a decrease in both chemical and whole body potassium concentration in pigs of 23 kg., 46 kg., and 91 kg. live weight.

This study was initiated to investigate the change in muscle tissue potassium and whole body potassium, determined by ^{40}K count, in steer calves from an "early maturing" breed and a "late maturing" breed.

Materials and Methods

Experimental animals utilized in this study were eight grade Angus and eight Charolais (7/8 Charolais x 1/8 Angus) steer calves. Whole body and muscle tissue potassium were determined at four periods during the preweaning life phase of the calves, beginning when the calves were about one month of age and at 56 day intervals thereafter.

Whole body poatssium was determined by means of the ^{40}K counter at the Oklahoma State University Live Animal Evaluation Center. Total ^{40}K count was expressed as gm K/kg. live weight.

Muscle tissue potassium was determined from live animal muscle biopsy samples (Guenther, 1972) obtained at each of the four test periods. The biopsy samples were frozen in liquid nitrogen and stored at —20°C until analyzed via atomic absorption spectroscopy. Muscle tissue potassium was expressed as mg K/gm wet tissue.

Results and Discussion

Results from the muscle tissue and whole body potassium analyses are presented in Table 1. These data indicated that as the calves matured during their pre-weaning life phase, muscle tissue potassium increased, while whole body potassium decreased in concentration.

The comparative changes in muscle tissue potassium between the Angus and Charolais calves are illustrated in Figure 1. It is apparent that the Angus calves were higher in muscle tissue potassium at Periods 1, 2, and 3 while the Charolais calves were higher at period 4. If tissue potassium is used as an indicator of "chemical maturity", these data suggest that the Angus calves were more mature (chemically) than the

Table 1. Mean Values for Potassium Concentration by Chemical Determination[1] and ^{40}K Count[2]

Variable	Breed	Period			
		1[3]	2[4]	3[4]	4[4]
Muscle Tissue Potassium[5]	Angus	32.61	32.79	34.60	35.23
	Charolais	27.71	28.61	30.41	37.68
Whole Body Potassium[6]	Angus	12.50	10.05	8.92	9.45
	Charolais	13.30	14.51	9.72	8.79

[1] Determined by atomic absorption spectroscopy
[2] Determined by ^{40}K whole body counter (calf counter)
[3] Average age for Angus = 41 day; Charolais = 32 days
[4] Increments of 56 days between Periods
[5] Expressed in mg potassium per gm wet tissue
[6] Expressed in gm potassium per kg live weight

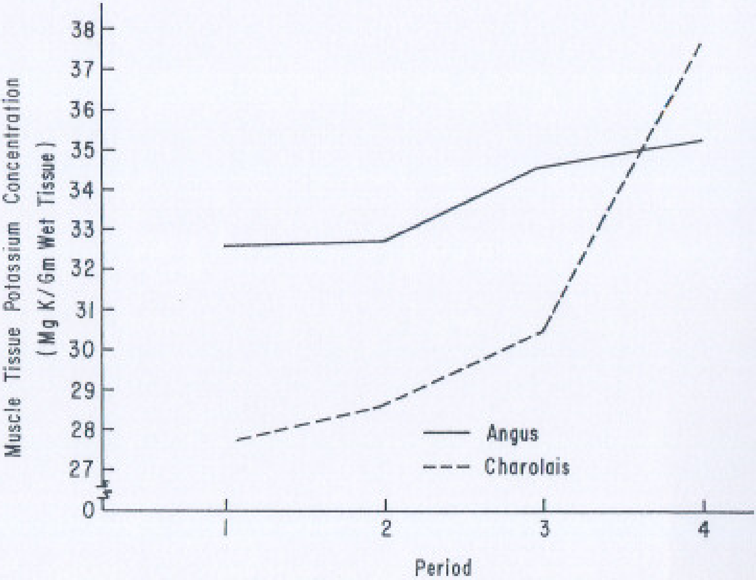


Figure 1. Concentration of Chemical Potassium in Muscle Tissue by Period

Charolais. This may best be evidenced by the increase in concentration within the Angus calves of only 8.03 percent, whereas the Charolais calves increased by 35.98 percent over the same span of life. This would indicate that the slower maturing (Charolais) breed is less chemically mature at birth than the faster maturing (Angus) breed.

Figure 2 illustrates the changes in whole body potassium between the two breeds during pre-weaning life. The smaller scale, more compact Angus calves were lower in whole body potassium than the larger scale, "growthy", Charolais calves. The Angus calves showed a decrease from 12.50 gm to 9.45 gm while the Charolais decreased from 13.30 gm to 8.79 gm during this phase of life. The Charolais calves were higher in whole body potassium at Periods 1, 2 and 3 and lower at Period 4 than the Angus calves.

Although the exact reasons for and signifance of the above findings must await further study, it would appear that whole body potassium content, as determined by ^{40}K count, is definitely influenced by the scale and surface area of the animal being counted. Consequently any prediction equation developed to estimate fat-free lean in the live bovine from ^{40}K count might have to include a "correction factor" to reflect differ-

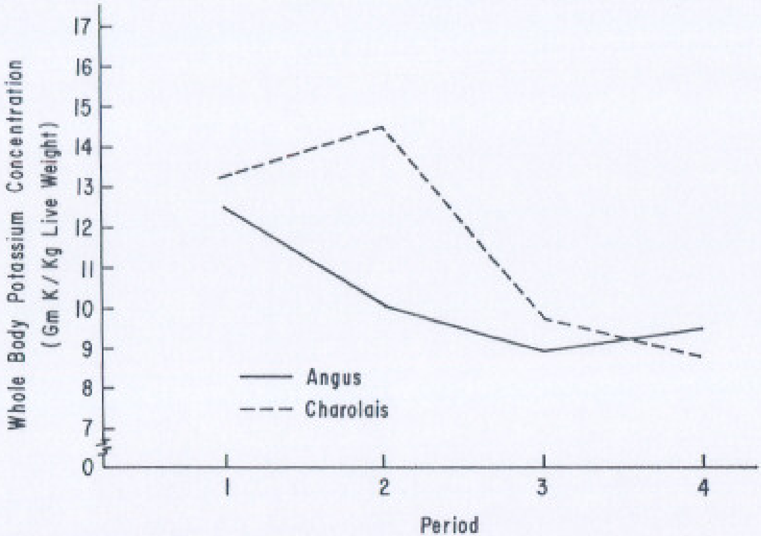


Figure 2. Concentration of Detectable Whole Body Potassium by Period

ences in animal scale and body mass, as this could improve the accuracy of any such estimate.

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Biochemical Studies on Bovine Growth and Development From Birth to Weaning

J. D. Gresham, J. J. Guenther and J. R. Escoubas

Story in Brief

Oxidative metabolic activity of muscle tissue was compared in eight small scale beef calves (Angus) and eight large scale beef calves (Charolais). Succinate dehydrogenase activity was determined spectrophotometrically by reduction of 2 (p-Iodophenyl) 3-p-nitrophenyl - 5-phenyl Tetrazolium Chloride (INT). Activity was determined on the dilute salt (0.2M Na_2 $HPO_4 \bullet 7$ H_2O, pH 7.5) soluble fraction of the whole tissue. Results indicated a decrease in activity from 4.73 x 10^{-2} units to 1.81 x 10^{-2} units over the 168 day evaluation period for the large scale calves.

The small scale calves had a reduction in net activity from 3.69 x 10^{-2} units to 2.59 x 10^{-2} units over the same phase. A slight increase in activity was noted for the small scale calves in Period 4 not noted in the large scale calves. These results suggest the small scale calves were more "chemically mature" at birth than the large scale calves.

Introduction

In general, skeletal muscles are composed of two basic fiber types, the Type I (Red) fiber which is rich in the oxidative enzymes and poor in phosphorylase and adenosine triphosphatase and the Type II (White) fiber which is poor in the oxidative enzymes and rich in phosphorylase and adenosine triphosphatase (Dubowitz and Pearse, 1960a, b). A third "intermediate" fiber type has been identified which shows a moderate reaction to oxidative enzymes but an intense reaction to phosphorylase and adenosine triphophatase (Brooke, 1966). It has also been shown that the type I fiber is the predominant fiber type in early postnatal life, whereas the Type II fiber becomes more prominent as chronological age increases. Some species are fully differentiated at birth, while in others fiber differentation occurs post-natally (Dubowitz, 1963, 1968). The state of fiber differentiation at birth is related to the length of gestation and physical maturity at parturition.

The purpose of this study was to compare the state of chemical maturity of an early maturing and late maturing bovine breed, utilizing oxidative enzyme changes associated with post-natal muscle fiber differentiation as an "index" of chemical maturity.

Materials and Methods

In this study, eight grade Angus steer calves were selected to represent the early maturing bovine breed and a similar number of Charolais (7/8 Charolais x 1/8 Angus) steer calves were selected to represent the later maturing breed. The test calves were kept with their dams until weaning (approximately 205 days of age), under similar range conditions. Muscle samples were obtained by live animal biopsy (Guenther, 1972) at approximately 35 days of age (Period 1) and at three subsequent 56 day periods (Periods 2, 3, and 4). Muscle samples were wrapped in aluminum foil, frozen in liquid nitrogen and stored at —20°C awaiting chemical analysis. Fiber differentiation was estimated by the determination of total oxidative and total glycolytic activity of the muscle tissue. Activity was measured spectrophotometrically by the enzymatic reduction of tetrazolium salts (Beecher, 1965) utilizing succinate dehydrogenase to represent the oxidative activity and lactate dehydrogenase for glycolytic activity.

Results

Results are presented as the period mean values for the eight animals within each breed. Units of activity are expressed as net change in optical density per 15 minute per mg. of extractable protein. Extractable protein is the dilute salt (0.2M $Na_2HPO_4 \bullet 7H_2O$, pH 7.5) soluble protein as determined by the Biuret method (Layne, 1957).

Figure 1 represents a comparison of the total oxidative activity of the two breeds by period. It is apparent that the initial oxidative activity of the Charolais calves was higher (4.73×10^{-2} units) than that of the Angus (3.69×10^{-2} units). This would indicate that the Charolais were less "chemically mature" at this phase of their lifetime than the Angus, based on the assumption that fiber differentiation results in the lowered oxidative capacity of the tissue.

Between Periods 1 and 2 (56 days) there was little difference in the rate of change between the two breeds (1.40×10^{-2} units for the Angus and 1.26×10^{-2} units for the Charolais). However, during the next 56 day increment (between Periods 2 and 3), the mean activity for the Angus decreased only 0.26×10^{-2} units whereas that of the Charolais decreased 1.38×10^{-2} units or 5.5 times the Angus difference. This apparent plateauing effect noted for the Angus calves may reflect a state of "chemical maturity" for the early maturing breed which was not yet apparent for the later maturing breed. Between Periods 3 and 4, a reduction in activity of only 0.28×10^{-2} units was noted for the Charolais which was quite similarto the 0.26×10^{-2} units of change between Periods 2 and 3 of the Angus.

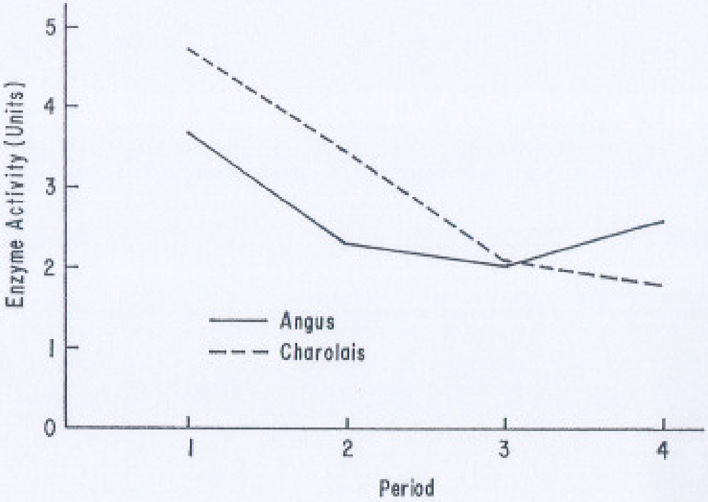

Figure 1. Total Oxidative Activity by Period

An increase in oxidative activity of 0.56 x 10^{-2} units was noted for the Angus calves between Periods 3 and 4. This increase in oxidative activity of the Angus may be indicative of biochemical adaptions of the muscle tissue associated with apparent completeness of skeleton development of the Angus (Gresham, et al. 1973). Figure 2 reflects the growth rate of the left metacarpal at each period between the two breeds. Note that there was a decline in rate of growth of the Angus between Periods 2 and 4, whereas the Charolais rate of growth was still linear. This implies that the Angus may have reached a state of "physiological maturity" not yet evident for the Charolais. Purportedly, the four major tissues develop in the order of nerve, bone, muscle, then adipose. Therefore, the completeness of bone growth would be followed by muscular development. This increased demand for protein synthesis has caused either a regression in the Angus of some Type II fiber back to Type I fibers or a stimulation of the oxidative activity of the muscle tissue.

Regression of fiber types has been reported to occur with starvation and subsequent high nutritional levels (Goldsprink, 1965). Several other workers (Dreyfus and Vibert, 1967; Goldberg, 1967) have shown that red muscle incorporates more amino acids into the sarcoplasmic and myofibrillar fractions than does white muscle. Further studies will, hopefully, define either the control mechanisms responsible for the increased oxidative capacity of the muscle tissue or what has stimulated the regres-

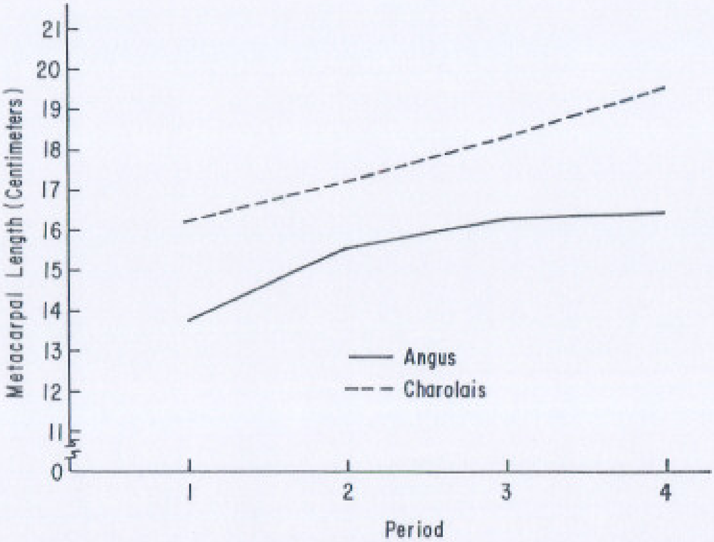

Figure 2. Metacarpal Length by Period

sion of the muscle fibers from glycolytic metabolism back to oxidative metabolism.

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Preliminary Studies on Breed Variations in the Rate of Deposition of Compact and Cancellous Bone During Pre-Weaning Growth in the Bovine

J. J. Guenther, L. E. Evans[1], J. D. Gresham and J. R. Escoubas

Story in Brief

Six Angus and six Charolais steer calves were used to study the influence of animal scale on the rate of compact and cancellous bone deposition during pre-weaning growth in the bovine. Experimental data were obtained from radiograms of the left metacarpal bone of each calf taken at four periods during the calves' pre-weaning life. From the radiograms, visual changes in the periosteal and metaphyseal regions of the metacarpal bones were evaluated via a subjective score, based on a scale of 1 to 6.

[1] Department of Radiology, College of Veterinary Medicine.

Both breeds exhibited significant increases in compact and cancellous bone tissue during pre-weaning growth. Data indicated that the metacarpal bones of the small scale calves matured in diameter more rapidly than in length. The small scale calves attained maximal rate of new bone deposition in the periostal and metaphyseal regions (of the metacarpal) during mid pre-weaning life. The large scale calves, however, had the greatest rate of new bone deposition during the last pre-weaning test period. Results suggest that small scale bovine attain a significant level of skeletal maturity prior to weaning or between 5 and months of age.

Introduction

Bone, especially long bone, though it may seem to be rather dense, t and inelastic is actually a very dynamic tissue, being extremely re- sive to existing environmental conditions, nutritional as well as iological.

Bone growth takes place when minerals are added to the tissue at a aster than they are withdrawn. Long bone may increase in both and diameter or thickness. An increase in the length of long bone mplished by adding new tissue to the surfaces of pre-existing bone area of the epiphyseal plates, causing an enlargement of the meta- The metaphyses are located at the proximal (top) and distal) ends of the long bone diaphysis or "shaft". Reportedly, in- n the length of long bone terminate when the epiphyseal plates when the bone reaches "physiological maturity".

eases in the diameter of long bone occur by adding new tissue face of pre-existing bone at the periosteal or "periphery" region g bone shaft. Bone deposition in the metaphyseal region is re- s carcellous or "spongy" bone, whereas at the periosteal region l compact or cortical bone.

urpose of this study was to compare changes in compact and bone deposition in the metacarpal bone of a large and small of beef cattle during their pre-weaning growth phase.

Materials and Methods

ental animals utilized in this study were six grade Angus d six Charolais steer calves (7/8 Charolais x 1/8 Angus). The were selected so as to represent the small scale breed, where- is calves were selected to represent the large scale breed. were kept with their respective dams, under similar range ing pre-weaning life.

tal data were obtained from radiographs of the left metacarpal bone of each animal. The radiog... periods during the calves' pre-weaning life, the first being ... the calves averaged 32 days of age and at 56 day intervals thereafter. From the radiograms the periosteal and metaphyseal regions of the metacarpal bones were evaluated, as well as epiphyseal plate closure. A subjective score, based on a scale of 1 to 6, was used to indicate visual changes in the above tissue areas.

Results and Discussion

At the outset of the experiment the six Angus calves ranged in ag from 2?-41 days, the Charolais, 24-39 days. The average age of all calv

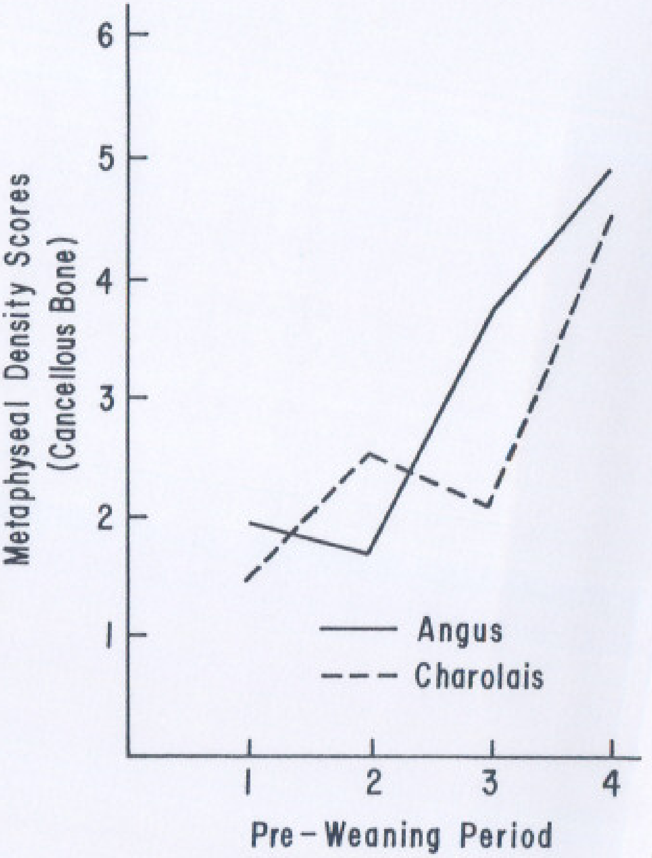

Figure 1. The influence of animal breed and scale on c deposition in the bovine during pre-weaning

at periods 1, 2, 3 and 4 was 32, 88, 144 and 200 days, respectively.

In Figure 1 are presented the mean metaphyseal density scores of the metacarpal bones from the two test breeds at the various pre-weaning periods. Visually, this region appeared as a sclerotic zone on the radiogram and what was actually evaluated was the amount of metaphyseal sclerosis. Whether the sclerotic zone was caused by actual new cancellous bone deposition or a reaction to an inflammatory condition, epiphysitis, engendered by some nutritional imbalance or physical stress or a combination of the above, cannot be fully elucidated at this time.

The discussion to follow is based on the assumption that the changes in the metaphyseal sclerotic area were due, primarily, to the deposition of new cancellous bone tissue. Results in Figure 1 show that both breeds

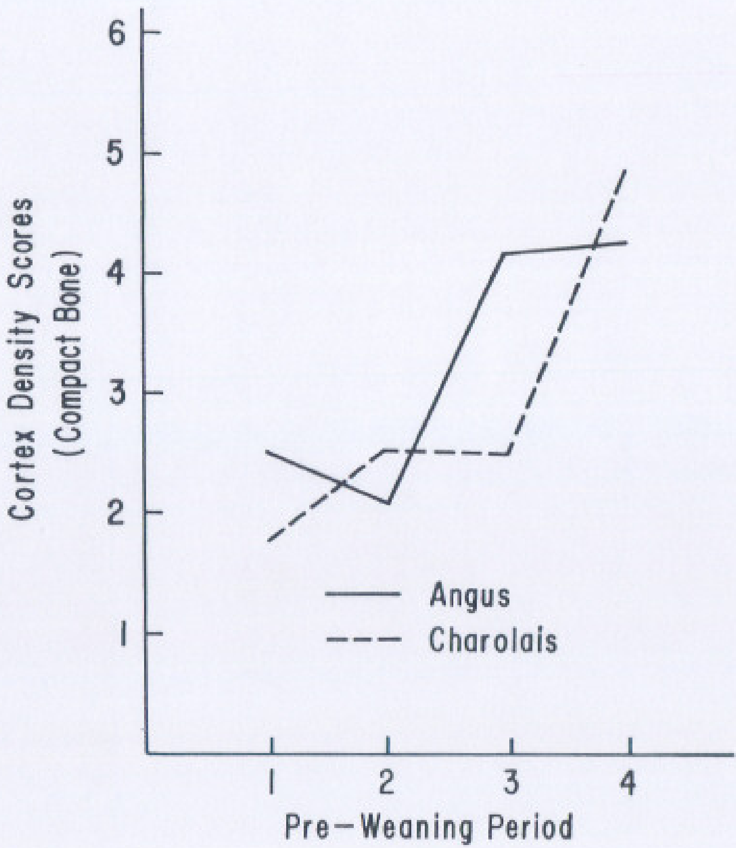

Figure 2. The influence of animal breed and scale on compact bone deposition in the bovine during pre-weaning life

displayed a net increase in new bone deposition, with the small scale Angus calves accumulating greater amounts than the large scale Charolais, except for period 2. A comparison of the curves, for the two breeds, between periods 3 and 4 indicates that the Angus calves had begun to decline in their rate of linear bone increase, or cancellous bone deposition, during this phase of their pre-weaning life. However, for the Charolais calves this was the period of maximum rate of linear bone deposition. Apparently, then, the Angus calves had attained a more advanced state of physiological maturity than did the Charolais during pre-weaning life.

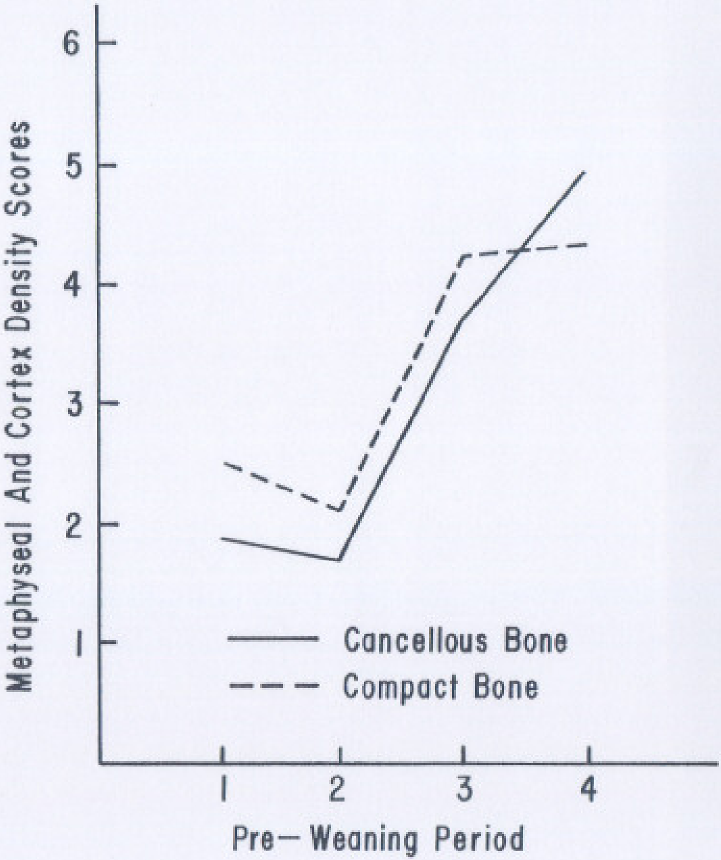

Figure 3. The relationship between compact and cancellous bone deposition in small scale (Angus) bovine during pre-weaning life

The rate of compact or cortical bone deposition was assessed via visual observation of the area and density of the cortex. These results are represented by the graphs in Figure 2. Although both breeds showed a net increase in compact bone deposition during pre-weaning life, it is obvious that the metacarpal bones of the small scale Angus calves matured in diameter or thickness at a much faster rate than did the larger scale Charolais. Moreover, at period 4, the Charolais had surpassed the Angus calves in total amount of cortical bone.

The relationship between metacarpal cancellous and compact bone formation is portrayed in Figures 3 and 4, respectively, for the Angus

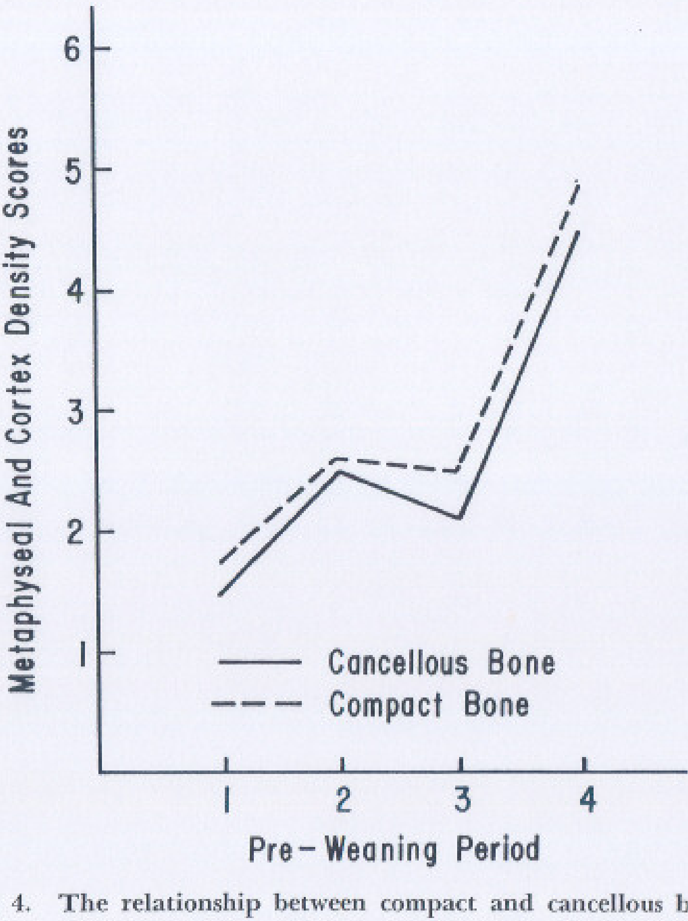

Figure 4. The relationship between compact and cancellous bone deposition in large scale (Charolais) bovine during pre-weaning life

and Charolais breeds. A positive relationship between these two types of bone deposition can be noted, for both breeds, through period 3. Between periods 3 and 4, however, compact bone deposition in the Angus calves decreased considerably, whereas in the Charolais calves it tended to parallel cancellous bone formation.

From the above data, it would appear that the metacarpal bones of small scale animals mature more rapidly in diameter than they do in length. Also, the results suggest that small scale bovine attain a notable degree of skeletal maturity prior to weaning or between 5 and 7 months of age.

Swine

Effect of Pellet Size on Pig Performance

W. G. Luce, I. T. Omtvedt, C. V. Maxwell, S. D. Welty
and D. C. Zoltner

Story in Brief

Two trials were conducted involving 208 growing-finishing pigs to study the effect of pellet size on performance of growing-finishing swine. The pigs were self fed in confinement from an average weight of 63.2 to 223.7 lb. and 48.7 to 201.2 lb. for Trials 1 and 2 respectively. Milo and wheat were the cereal grains used in Trials 1 and 2, respectively.

The treatments involved in both trials were a meal ration, a 3/16 inch pellet ration, a 1/4 inch pellet ration, and a 3/8 inch pellet ration. Pelleting tended to improve average daily gains and feed efficiency in both trials. Size of pellets had little affect on the pigs fed milo rations in Trial 1 but tended to favor the smaller size pellets (3/16 and 1/4 inch) for the pigs fed the wheat rations in Trial 2.

Introduction

Previous research conducted in the Department of Animal Sciences and Industry has shown that pelleting of a milo-soybean meal or a wheat-soybean meal ration resulted in approximately a 7 percent improvement in average daily gains and a 10 percent improvement in feed efficiency for growing-finishing swine.

Since research work here and at other research stations indicated advantages of pelleting swine rations, it was deemed feasible to study the optimum pellet size for growing-finishing swine. Traits studied included average daily gain, feed efficiency, feed intake and probed backfat thickness.

Experimental Procedure

All pigs were housed in indoor concrete pens equipped with self feeders and waterers. In both trials the pigs were randomly alloted within breed, sex and litter to four experimental treatments. Pigs were fed

In cooperation with USDA Agricultural Research Service, Southern Region.

either a meal form ration or a pelleted ration prepared by a California Master Model Pellet Mill at the Oklahoma State University Feed Mill.

Trial 1

Trial 1 consisted of 64 purebred Hampshire or Yorkshire pigs with eight pens (two pigs per pen) on each of four treatments. A 16 percent crude protein milo-soybean meal ration as shown in Table 1 was self fed to all pigs from an average weight of 63.2 lb. to 223.7 lb. Treatments involved were (1) a meal ration, (2) a 3/16 inch pellet ration, (3) a 1/4 inch pellet ration and (4) a 3/8 inch pellet ration. Pigs were individually removed from treatment on a weekly basis when they reached 220 lb.

Trial 2

Trial 2 consisted of 144 purebred Duroc, Hampshire or Yorkshire gilts with four pens (nine pigs per pen) on each of four treatments. A 16 percent crude protein wheat-soybean meal ration as shown in Table 1 was self fed to all pigs from an average weight of 48.7 lb. to 201.2 lb. Treatments involved were (1) a meal ration, (2) a 3/16 inch pellet ration (3) a 1/4 inch pellet ration and (4) a 3/8 inch pellet ration. Pigs were individually removed from treatment on a weekly basis when they reached 200 lb.

Results and Discussion

Trial 1

The results of Trial 1 are shown in Table 2. Pigs on treatment 3 (1/4 inch pelleted ration) had the highest average daily gain and was

Table 1. Composition of Experimental Rations

	Trial 1	Trial 2
Ingredients, %		
Milo, ground	68.00	-
Wheat, ground	-	75.10
Soybean meal (%)	22.75	16.75
Molasses (wet)	5.00	5.00
Calcium carbonate	0.70	0.80
Dicalcium phosphate	1.50	1.30
Salt	0.50	0.50
Vitamin-trace mineral mix[1]	0.50	0.50
Aureomycin 10	0.25	0.25
Aureomycin 50	-	0.05
Total	100.00	100.00
% protein	16.01	16.01
% calcium	0.71	0.71
% phosphorous	0.60	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.

Tabel 2. Effect of Pellet Size on Pig Performance—Trial 1

	1 (meal form)	2 (3/16 in. pellet)	3 (1/4 in. pellet)	4 (3/8 in. pellet)
Pens per treatment, no.	8	8	8	8
Pigs per pen, no.	2	2	2	2
Av. initial wt., lb.	63.1	63.2	64.3	62.0
Av. final wt., lb.	223.1	223.6	226.1	221.9
Av. daily gain, lb.[1]	1.75^{1}	$1.82^{1,2}$	1.88^{2}	$1.82^{1,2}$
Av. daily feed intake, lb.	5.84	5.53	5.73	5.52
Feed per lb. gain, lb.[1]	3.36^{1}	3.04^{2}	3.05^{2}	3.04^{2}

[1] Means with different superscripts are significantly different (P<.05).

significantly higher than those on treatment 1, (meal form ration). Pigs on treatment 2 (3/16 inch pelleted ration) and treatment 4 (3/8 inch pelleted ration) also had higher average daily gains than those on treatment 1. Pigs on treatment 1 (meal form ration) required significantly more feed per pound of gain than the pigs on the other treatments.

No significant differences were noted in average daily feed intake but the pigs on the pelleted rations tended to consume less. This feed savings may largely result from a reduction in feed wastage. While pelleting in general tended to improve average daily gains and feed efficiency, little difference was noted due to size of pellets.

Trial 2

The results of Trial 2 are shown in Table 3. Pigs on all the pelleted rations had higher average daily gains than those on the meal form ration. Pigs on Treatment 2 (3/16 inch pellet ration) had the highest average daily gain and was significantly higher than those on treatment

Table 3. Effect of Pellet Size on Pig Performance — Trial 2

	1 (meal form)	2 (3/16 in. pellet)	3 (1/4 in. pellet)	4 (3/8 in. pellet)
Pens per treatment, no.	4	4	4	4
Pigs per pen, no.	9	9	9	9
Av. initial wt., lb.	49.2	48.4	48.6	48.6
Av. final wt., lb.	200.5	203.1	201.4	199.8
Av. daily gain, lb.[1]	1.52^{1}	1.65^{2}	$1.60^{2,3}$	$1.56^{1,3}$
Av. daily feed intake, lb.	4.55	4.70	4.75	4.71
Feed per lb. gain, lb.[1]	3.01^{1}	2.85^{2}	2.97^{1}	3.02^{1}
Av. adjusted backfat, in.	1.15	1.16	1.13	1.12

[1] Means with different superscripts are significantly different (P<.05).

1 (meal form ration) and treatment 4 (3/8 inch pellet ration). Pigs on treatment 2 required significantly less feed per pound of gain than those on treatment 1.

No significant differences were noted in average daily feed intake or probed backfat thickness. Pelleting in general tended to improve average daily gains and the smallest size pellet (3/16 inch) tended to result in the best feed efficiency.

The Effect of Ration Ingredient Change on Pig Performance

W. G. Luce, C. V. Maxwell and D. C. Zoltner

Story in Brief

Two trials were conducted involving 128 growing-finishing pigs to measure the effect of marked ration ingredient change on pig performance.

Treatments involved in both trials were (1) a basal milo-soybean meal ration fed throughout the trials; (2) the cereal grain portion of the rations (milo, corn, and wheat) was rotated every 7 days; (3) the protein source (all soybean meal, ⅓ meat and bone scraps and ⅔ soybean meal, and ⅓ peanut meal and ⅔ soybean meal) was rotated every 7 days; (4) both the cereal grain and protein sources, as outlined in Treatments 2 and 3 were rotated every 7 days (nine different combinations).

No significant differences were noted in average daily gains, average daily feed intake, feed efficiency and probed backfat thickness. The results suggest that marked ration ingredient changes has little effect on pig performance when nutritional requirements are met.

Introduction

It is now possible through the use of high speed electronic computors to overcome many of the physical problems formerly associated with formulating least cost, nutritionally adequate rations from a wide number of available feedstuffs. This method of ration formulation commonly referred to as linear programming has gained some acceptance by industry and university personnel working in the area of swine nutrition.

One concern of many nutritionists and swine producers was that frequently the prices of commodities fluctuate enough from week to week to greatly influence the ingredients selected by the computor in a least cost ration. Thus the purpose of these experiments was to study the effect of marked ration ingredient change in the pig's diet on rate of gain, daily feed intake, feed utilization and probed backfat thickness.

Experimental Procedure

Two trials involving 128 purebred Hampshire or Yorkshire pigs were used in this experiment. All pigs were housed in indoor concrete pens equipped with self feeders and automatic waterers. All pigs were self fed from an average weight of 71.5 and 57.6 lb. to 213.9 and 222.2 lb. in trials 1 and 2 respectively. In both trials the pigs were randomly allotted within breed, sex and litter to four experimental treatments with eight pens (two pigs per pen) in each treatment.

The four treatments in both trials were as follows:

1. Treatment 1. A basal 16.0 percent crude protein milo-soybean meal ration was fed throughout both trials. (See ration 1 in Tables 1 and 2 for Trials 1 and 2 respectively.
2. Treatment 2. The cereal grain portion of the ration (milo, corn and wheat) was rotated every seven days. (See rations 1, 2 and 3 in Tables 1 and 2 for Trials 1 and 2 respectively.)
3. Treatment 3. The protein sources (all soybean meal, ⅓ meat and bone scraps and ⅔ soybean meal, and ⅓ peanut meal and ⅔ soybean meal) were rotated every seven days. (See rations 1, 4 and 5 in Tables 1 and 2 for Trials 1 and 2 respectively.
4. Treatment 4. Both the cereal grain and protein sources as outlined in Treatment 2 and 3 were rotated every 7 days. This was a total of nine different combinations. The combinations were: milo and soybean meal, milo and ⅓ meat and bone scraps and ⅔ soybean meal, milo and ⅓ peanut meal and ⅔ soybean meal, corn and soybean meal, corn and ⅓ meat and bone scraps and ⅔ soybean meal, corn and ⅓ peanut meal and ⅔ soybean meal, wheat and soybean meal, wheat and ⅓ meat and bone scraps and ⅔ soybean meal and wheat and ⅓ peanut meal and ⅔ soybean meal. (See rations 1 through 9

Table 1. Composition of Experimental Rations in Trial 1

	Ration number[1]								
	1	2	3	4	5	6	7	8	9
Ingredients, %									
Milo, ground[2]	74.20	–	–	78.00	76.25	–	–	–	–
Wheat, ground[2]	–	84.70	–	–	–	87.00	86.00	–	–
Corn, ground[2]	–	–	73.50	–	–	–	–	77.30	75.30
Soybean meal, 44%	22.50	12.10	23.40	13.80	13.60	7.20	7.20	14.30	14.20
Meat and bone scraps, 50%	–	–	–	6.90	–	3.60	–	7.15	–
Peanut meal, 50%	–	–	–	–	6.80	–	3.60	–	7.10
Calcium carbonate	0.90	0.90	0.80	0.15	0.85	0.60	0.90	0.15	0.80
Dicalcium phosphate	1.40	1.30	1.50	0.15	1.50	0.60	1.30	0.10	1.60
Vitamin-trace mineral mix[3]	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Composition, %									
Protein	15.99	16.01	16.00	16.01	15.98	15.99	15.99	15.98	16.01
Lysine[4]	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73
Calcium	0.71	0.70	0.70	0.69	0.70	0.71	0.70	0.71	0.72
Phosphorus	0.60	0.61	0.60	0.60	0.61	0.60	0.60	0.59	0.61

[1] Tylan 40 was added at the rate of 0.05% for each ration.
[2] The milo, wheat and corn analyzed 8.6, 12.8 and 8.2% crude protein respectively.
[3] Vitamin-trace mineral mix supplied 1500 I.U. vitamin A, 150 I.U. vitamin D_3, 2 mg. riboflavin, 15 mg. niacin, 10 mg. pantothenic acid, 500 mg. choline, 7.5 mcg. vitamin B_{12}, 0.22 ppm iodine, 99 ppm iron, 22 ppm manganese, 11 ppm copper and 99 ppm zinc per pound of feed.
[4] 0.03, 0.19, 0.07, 0.15, 0.24, 0.26, 0.09 and 0.13% L-lysine added to rations 1,2,4,5,6,7,8, and 9 respectively to make them equivalent in lysine content to ration 3.

Table 2. Composition of Experimental Rations in Trial 2

	Ration number[1]								
	1	2	3	4	5	6	7	8	9
Ingredients, %									
Milo, ground[2]	75.20	–	–	78.70	76.25	–	–	–	–
Wheat, ground[2]	–	83.10	–	–	–	85.55	83.90	–	–
Corn, ground[2]	–	–	76.60	–	–	–	–	79.90	77.70
Soybean meal, 44%	21.50	13.70	20.00	13.30	13.60	8.30	8.60	12.30	12.60
Meat and Bone scraps, 50%	–	–	–	6.65	–	4.15	–	6.15	–
Peanut meal, 50%	–	–	–	–	6.80	–	4.30	–	6.30
Calcium carbonate	0.80	0.90	0.80	0.15	0.85	0.50	0.90	0.15	0.80
Dicalcium phosphate	1.50	1.30	1.60	0.20	1.50	0.50	1.30	0.50	1.60
Vitamin-trace mineral mix[3]	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Composition, %									
Protein	16.00	16.02	16.00	16.02	16.01	16.01	16.01	16.00	15.99
Lysine[4]	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
Calcium	0.70	0.70	0.71	0.69	0.71	0.70	0.70	0.71	0.70
Phosphorous	0.61	0.61	0.61	0.60	0.61	0.61	0.60	0.61	0.61

[1] Tylan 40 was added at the rate of 0.05% for each ration.
[2] The milo, wheat and corn analyzed 8.70, 12.02 and 9.40% protein respectively.
[3] Vitamin-trace mineral mix supplied 1500 I.U. vitamin A, 150 I.U. vitamin D_3, 2 mg. riboflavin, 15 mg. niacin, 10 mg. pantothenic acid, 500 mg. choline, 7.5 mcg. vitamin B_{12}, 0.22 ppm iodine, 99 ppm iron, 22 ppm manganese, 11 ppm copper and 99 ppm zinc per pound of feed.
[4] 0.15, 0.03, 0.06, 0.11, 0.19, 0.23, 0.09 and 0.15% L-lysine added to rations 2 through 9 respectively to make them equivalent in lysine content to ration 1.

in Tables 1 and 2 for Trials 1 and 2 respectively.)

In both trials vitamin and trace mineral supplementation, calcium, phosphorous, crude protein and lysine were held constant in all rations. All other amino acids were calculated to be at least above requirement stated by the National Research Council, 1968 but not constant in all rations. Energy content was similar in all rations.

Results and Discussion

The results of Trial 1 and 2 are shown in Tables 3 and 4 respectively. Average daily gain, feed efficiency and average daily feed intake was similar for pigs on all treatments in both trials with no significant differences being noted. When probed backfat thickness was measured in Trial 2, the results were similar for pigs on all treatments and no significant differences were noted.

Table 3. Effect of Ration Ingredient Change on Pig Performance in Trial 1

	Treatments			
	1	2	3	4
Pens per treatment, no.	8	8	8	8
Pigs per pen, no.	2	2	2	2
Av. initial wt., lb.	70.9	71.4	70.9	72.9
Av. final wt., lb.	214.0	214.7	213.3	213.4
Av. daily gain, lb.*	1.82	1.79	1.77	1.81
Feed per lb. gain, lb.*	3.14	3.05	3.13	3.11
Av. daily fed intake, lb.*	5.63	5.56	5.52	5.56

*Treatment means were not significantly different at the (P<.05) level.

Table 4. Effect of Ration Ingredient Change on Pig Performance in Trial 2

	Treatments			
	1	2	3	4
Pens per treatment, no.	8	8	8	8
Pigs per pen, no.	2	2	2	2
Av. initial wt., lb.	57.3	58.7	58.2	56.3
Av. final wt., lb.	223.9	223.5	221.1	220.1
Av. daily gain, lb.	1.74	1.73	1.77	1.71
Feed per lb., gain, lb.*	3.22	3.05	3.19	3.08
Av. daily feed intake, lb.*	5.56	5.25	5.62	5.23
Probed backfat thickness, in.*	1.00	1.00	1.05	1.09

*Treatment means were not significantly different at the (P<.05) level.

It would appear that marked ration ingredient change has little effect on pig performance. However it should be noted that in these trials, all known nutritional requirements were believed to be met on all diets fed. Furthermore, ingredients or level of ingredients used were those believed to be palatable to swine.

Effect of Protein Level on Nitrogen Balance and Reproductive Performance in Gilts

Rick D. Jones, Charles V. Maxwell,
David C. Zoltner and Rollie E. Ennis

Story in Brief

Three trials involving a total of 90 gilts were conducted to evaluate the effect of crude protein intake on growth, nitrogen balance and reproductive performance of breeding gilts. Yorkshire gilts were fed graded levels of protein from approximately 146 days of age to slaughter at 30 days post-breeding.

Feeding a high protein ration (20 percent crude protein) resulted in little or no advantage in average daily gain to puberty, age at purberty or nitrogen retention prior to breeding when compared to the medium level diet (14 percent). Gilts fed the low protein ration (8 percent) gained significantly slower and tended to be older at puberty than gilts fed the 14 or 20 percent protein rations. The high protein diet (20 percent) resulted in a significantly greater nitrogen retention during early pregnancy.

The value of this increased nitrogen retention is not well understood. An increase in anestrous gilts seemed to be associated with the two lower protein levels; however, sufficient data were not obtained in

this study to establish a definite relationship. Number of corpora lutea, an indicator of ovulation rate, increased as protein level increased. Number of live embryos and percent embryo survival were not affected by protein levels used in this experiment.

Introduction

Recent research has raised many questions as to the effects of dietary protein levels, fed before and after breeding, on subsequent reproductive performance in gilts. Reproductive performance, as assessed by litter size, birth weight and pig survival to weaning, has proven to be unresponsive to differences in protein intake during gestation. Variation in litter size due to boar influence, season, crowding effect in the uterus and other environmental factors have made it difficult to show an effect on litter data due to protein intake of the dam.

Nitrogen retention can be used to indicate the level of dietary protein which maximizes body protein synthesis; however, this technique does not differentiate between protein synthesis that is required for optimal reproduction and that which is simply stored protein. This study was undertaken to determine the effect of feeding various levels of crude protein, over an extended period of time, on the reproductive performance, nitrogen retention and growth of young gilts.

Materials and Methods

Three trials were conducted using 90 Yorkshire gilts averaging 146 days of age. Ten gilts were randomly allotted to each of the three dietary protein levels within each of the three trials. The three rations (Table 1) were calculated to have 20, 14 or 8 percent crude protein. The 20 percent ration was a milo-soybean meal based ration and the 14 and 8

Table 1. Composition of Experimental Rations

Ingredient	20% C. P.	14% C. P.	8% C. P.
Milo (8%)	68.52	47.96	27.41
Soybean meal (50.9%)	28.50	19.95	11.40
Corn starch		28.61	57.39
Dicalcium phosphate	0.64	1.30	1.89
Limestone	1.34	1.18	0.91
Vit-Mineral premix[1]	0.50	0.50	0.50
Salt	0.50	0.50	0.50

[1] Vitamin-trace mineral premix supplied 1500 IU vitamin A, 150 IU vitamin D_3, 2 mg riboflavin, 15 mg niacin, 10 mg pantothenic acid, 500 mg choline, 7.5 mcg vitamin B_{12}, 0.22 ppm iodine, 99 ppm iron, 22 ppm manganese, 11 ppm copper and 99 ppm zinc per pound of feed.

percent protein rations were made by diluting the 20 percent ration with corn starch which contains virtually no protein. Constant amino acid ratios across treatments were maintained by this procedure. Adequate calcium (0.75 percent), phosphorus (0.50 percent), vitamins, trace minerals and salt were added to all three rations.

The rations were fed to their respective treatment groups at a level of 5 pounds per gilt per day until the group averaged 180 days of age, then the level was reduced to 4 pounds daily giving approximately .80, .56 or .32 pounds of crude protein daily to the respective treatment groups.

The gilts were fed once daily in individual feeding stalls and had access to drinking water and shelter. Gilts were checked daily for signs of estrus by introducing a teaser boar into the pen. Ages at first and second estrus were recorded and an attempt was made to breed all gilts on the third estrus (second post-puberal) with natural services on two consecutive days. Weights were taken every two weeks to monitor growth.

Two five-day nitrogen balance studies were conducted on a random sample of the gilts. Gilts were put into crates equipped for feces and urine collection on day 11 after the second estrus and again on day 21 after breeding. A two-day adjustment period was allowed, then feces were weighed daily and urine volume was measured daily. Ten percent of each daily urine and fecal collection was frozen for nitrogen analysis by the Kjeldahl procedure.

Gilts were slaughtered at approximately 30 days post-breeding and the entire reproductive tracts were removed. Ovaries were examined for numbers of corpora lutea and live embryos were counted and measured for length. All data was analyzed by the least squares procedure with number of live embryos and percent embryo survival adjusted to equal numbers of corpora lutea and embryo length adjusted to equal age of embryo. Differences in least squares means were tested for significance by Student's "t" test.

Results and Discussion

Total weight gain and average daily gain from the first day on test to date of first estrus were used to evaluate the effect of level of protein on growth (Table 2). Average daily gain increased with increasing protein intake; however, rate of gain was apparently beginning to plateau at the high level of intake. Gilts fed the low protein level (.32 pounds) gained significantly slower than gilts fed .56 or .80 pounds of protein. These data suggest that protein was a limiting factor in growth of the gilts; however, none of the treatments resulted in optimal weight at recommended breeding age. Energy restriction may have been too severe for these gilts.

The mean ages at first, second and third estrus (Table 3) tended to increase with decreasing protein intakes, but this trend was not significant (P<.1). These data did now show the estrual cycle irregularities which tended to be associated with the two lower protein levels (Table 4). Only one gilt (3.6 percent of total) fed the 20 percent ration failed to exhibit estrus, whereas seven (23.3 percent) and six (20.7 percent) anestrous gilts were observed in the groups fed 14 and 8 percent protein, respectively.

This study did not provide sufficient data to show a significant increase in anestrous gilts on the lower protein intakes. However, this form of reproductive failure might be the most serious problem encountered in gilts on low protein diets.

Table 2. Total Weight Gain and Average Daily Gain to First Estrus

	20% C. P.	14% C. P.	8% C. P.
No. of gilts exhibiting estrus[1]	27	28	25
Total weight gain, lb.	77.2	76.8	69.0
Average daily gain, lb.[2]	.96[1]	.93[1]	.74[2]

[1] One gilt died and one crippled gilt removed from 20% group and one gilt died in 8% group.
[2] Values without a common letter differ significantly (P<.001).

Table 3. Age at First, Second and Third Estrus[1]

	20% C. P.	14% C. P.	8% C. P.
First estrus	226.7	229.9	238.0
Second estrus	248.5	249.3	259.6
Third estrus	268.9	269.3	279.0

[1] Age in days.

Table 4. Estrus Irregularities Observed

	20% C. P.	14% C. P.	8% C. P.
No. of gilts on trial[1]	28e	30	29
No. of anestrous gilts	1	2	4
No. of gilts exhibiting estrus once	–	1	–
No. of gilts exhibiting estrus twice	–	4	2
Total anestrous at breeding	1	7	6

[1] One gilt died and one crippled gilt removed from 20% group and one gilt died in 8% group.

Boaz (1962) and Pond *et al.* (1968) found similar increases in anestrous gilts and sows fed low protein diets; however, numbers were too small to justify association of treatments with reproductive failures.

Fecal, urinary and retained nitrogen for collection periods I (before breeding) and II (after breeding) are presented in Table 5. Before breeding, the 20 and 14 percent protein rations appeared to allow maximum nitrogen retention with high, medium and low protein intake giving 14.2, 14.9, and 10.2 grams of retained nitrogen, respectively. These values suggest that an intake of 4 pounds of the 14 percent protein diet is adequate for protein tissue development before breeding. At this stage of development in the gilt, most of the protein absorbed from the gut is probably used in maintenance and growth of structural muscles (ham, loin, etc.) with only a very small amount going to development of the reproductive tract.

Collection period II was conducted on days 23 through 27 post-breeding and was probably well after implantation of the embryo in the uterus. Nitrogen retention increased linearly with increasing protein levels (P<.01), and the 20 percent protein ration allowed a significantly greater (P<.05) nitrogen retention (21.0 grams per day) than the 14 or 8 percent rations (9.8 and 7.2 grams, respectively).

This increased retention might indicate that the 20 percent ration fed at 4 pounds per day allowed greater protein synthesis than the 14 or 8 percent diets. This additional protein may have been deposited in uterine or mammary tissue or used for growth of structural muscle. It is also possible that the extra nitrogen retained was stored as "protein reserves" in the liver, muscles, skin, etc., Advantages of increased nitrogen retention with respect to gestation and parturition performance are not well documented.

Pregnant gilts retained slightly less nitrogen than non-pregnant gilts fed the two lower protein rations. This decreeased retention might

Nitrogen Balance of Gilts Fed Graded Levels of Protein

	20% C. P.	14% C. P.	8% C. P.
		Collection Period I	
	33.4[1]	19.2[2]	8.8[3]
	7.2	6.5	3.9
	14.2	14.9	10.2
		Collection Period II	
	26.8[1]	25.9[1]	11.6[2]
	8.2[1]	6.3[1,2]	3.8[2,4]
	21.0[1]	9.8[2]	7.2[2]

In grams per day.
a common letter differ significantly (P<.01) and linear effect significant (P<...).
a common letter differ significantly (P<.05) and linear effect significant (P<...).

ndicate an increased requirement for some essen... ..
mset of pregnancy. The calculated first-limiting amino acid in the experimental rations was methionine.

Reproductive performance is summarized in Table 6. Number of corpora lutea increased as protein intake increased. Each increase in protein level resulted in an average increase of .9 ova or potential embryos. No differences in live embryo numbers, percent survival or lengtl of embryos were observed. This suggests that reproductive efficienc during early gestation was not severely impaired by the feeding of re atively low levels of protein. However, Pond *et al.* (1969) found th: higher protein levels fed during the first 24 days of pregnancy signi cantly improved birth weight and postnatal growth rate of pigs. Hold *et al.* (1968) noted that increased protein intake during gestation i proved subsequent lactation and growth of offspring.

In conclusion, high protein levels fed before and after breedi seem to produce a slight improvement in overall reproductive per mance; however, numbers of gilts used in this experiment were not ficient to establish a relationship between increased protein intake greater reproductive efficiency.

Table 6. Reproductive Performance

	20% C. P.	14% C. P.	8% C
No. of corpora lutea[1]	14.7	13.8	12.
No. of live embryos	10.3	9.3	10
Percent survival	77.4	68.7	74
Embryo length, in.	1.03	1.03	1

[1] Linear effect significant ($P<.05$).

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Feedlot Performance and Carcass Merit of 2-Breed and 3-Breed Cross Pigs

R. K. Johnson, I. T. Omtvedt, L. E. Walters and T. W. Williams

Story in Brief

This study was initiated to evaluate differences in the feedlot performance and carcass merit for 2-breed and 3-breed crosses involving the Duroc, Hampshire and Yorkshire breeds. The data included the post-weaning feedlot performance on 606 barrows and gilts and the carcass data on 110 barrows.

There were no significant differences between 3-breed and 2-breed crosses for any of the feedlot and carcass traits evaluated. Overall, 2-breed and 3-breed cross pigs had nearly identical growth rates, feed consumption and feed efficiencies. The ½ Hampshire: ¼ Duroc: ¼ Yorkshire crossbred gilts had less backfat than the other groups and this resulted in the backfat thickness for the 3-breed crosses being 0.05 in. less than that for the 2-breed cross gilts. The carcasses from the 3-breed and 2-breed cross barrows were nearly the same for length, backfat thickness and loin eye area. The 2-breed cross carcasses averaged slightly higher yield of lean and higher color score but had a somewhat lower quality score for marbling.

In general, there appeared to be little added heterosis from 3-breed crosses over 2-breed crosses for measures of feedlot performance and carcass traits. Some interesting differences in performance between reciprocal crosses were noted, but more data are needed before drawing any definite conclusions regarding the relative importance of maternal effects.

In cooperation with USDA Agricultural Research Service, Southern Region.

Introduction

Growth rate and meat quality are moderately heritable traits in swine and have responded to crossbreeding, but the amount of heterosis observed appears to depend on which breeds are involved in the cross. Most swine carcass measurements (length, loin eye area, backfat thickness, and weight of the lean cuts) are in general highly heritable traits and have shown little response to crossbreeding.

Research has shown that a crossbred sow is needed in order to maximize production by capitalizing on the heterosis of a crossbred sow for preweaning performance. However, information on differences between specific crossing sequences is not available. Swine producers need to know which combinations yield the greatest advantage in terms of combining the strong points of the different breeds for feedlot performance and carcass merit.

This report deals with the second phase of the Oklahoma crossbreeding project where 2-breed and 3-breed crosses are compared for feedlot performance and carcass merit. The data includes only pigs farrowed in the 1972 spring at Ft. Reno, and the number of animals within any breed group are rather limited. The same breeding structure was repeated to produce litters in 1972 fall and these additional records are needed in order to provide sufficient numbers to evaluate the influence of maternal effects in crossing sequences. This report deals primarily with the relative differences between 2-breed and 3-breed cross pigs.

Experimental Procedure

The data included 606 gilts and barrows involving 2-breed and 3-breed crosses among Durocs, Hampshires and Yorkshires. The pigs were farrowed in the Ft. Reno swine breeding herd in 1972 spring. The feedlot records included 280 two-breed cross and 326 three-breed cross pigs and the carcass data included 55 two-breed cross barrows and 55 three-breed cross barrows.

The pigs used in this study came from litters that were produced by mating purebred boars of each breed to two gilts of each breed-type not represented in the boar. For example, each Duroc boar was mated to two Hampshires, two Yorkshires and to four Hampshire-Yorkshire crossbred gilts (two of each reciprocal breed-type).

The pigs were weaned at 42 days of age and two weeks later were moved to the confinement finishing barn. They were allotted by breed group in groups of about 16 pigs per pen and given a one-week adjustment period before being weighed on test. All pigs were self-fed a 16 percent crude protein (milo, wheat, soybean meal) ration until they reached 220 lbs. Pigs were weighed off test on a weekly basis as they reached 220 lbs., and all gilts (a total of 304) were probed for backfat at that time. As the pigs were weighed off test, a random sample of about nine barrows per breed group were taken to the University Meat Laboratory and evaluated for carcass merit.

Results

The growth rate, feed consumption and probe backfat data for the 2-breed and 3-breed crosses are presented in Table 1. The overall rate of gain and days to 220 lbs. was nearly identical for the 2-breed and 3-breed crosses. There was no significant difference in rate of gain or days to 220 lbs. among the various 2-breed crosses, but the ½ Duroc:¼ Hampshire: ¼ Yorkshire crossbred pigs gained 0:06 lbs. per day less than the other 3-breed crosses. The 3-breed cross gilts had 0.05 in. less backfat than the 2-breed crosses, but this superiority was primarily due to the ½ Hampshire:¼ Duroc:¼ Yorkshire crossed gilts having significantly less backfat than any of the other breed groups.

There was virtually no difference in average daily feed consumption or feed efficiency between the 2-breed and 3-breed crosses. Hampshire X Duroc-Yorkshire crosses consumed significantly less feed and were more efficient feed converters than the Yorkshire X Duroc-Hampshire crosses.

The carcass measurements for the 110 barrows slaughtered are presented in Table 2. In general, there was very little difference between the 2-breed and 3-breed crosses for carcass merit. The 3-breed crosses tended to have slightly less lean yield, higher marbling scores and lower color scores than 2-breed crosses although these differences were not significant. Duroc-Hampshire 2-breed cross barrows tended to have less backfat and less lean yield than other 2-breed crosses while Hampshire X Duroc-Yorkshire 3-breed crosses were longer, less fat and had more lean yield than did the other 3-breed crosses. Duroc-Yorkshire 2-breed cross barrows had higher marbling, firmness and color scores than the other 2-breed crosses while Hampshire X Duroc-Yorkshire crosses had somewhat lower quality scores than other 3-breed crosses.

Results from the first phase of this study have shown rather large differences in reciprocal crosses in the production of 2-breed cross pigs. Although the numbers in the present study are limited, the results are very similar to those of the first phase. There was little difference between reciprocal crosses involving Hampshires and Durocs for either feedlot performance or carcass traits. However, the Yorkshire crossbred pigs tended to grow faster and more efficiently and to have more desirable carcasses when the Yorkshire served as their dam breed rather than their sire breed. These differences were especially evident for the reciprocal crosses involving Durocs and Yorkshires. These data suggest that there

Table 1. Postweaning Performance and Probe Backfat Data for 2-Breed and 3-Breed Cross Pigs

	2-Breed Crosses[1]			3-Breed Crosses[2]			Overall		
	D-H	D-Y	H-Y	DxH-Y	HxD-Y	YxD-H	2-Breed Crosses	3-Breed Crosses	% Imprvmt. over 2-Breed
Growth Rate:									
No. pigs	95	97	88	106	105	115	280	326	
Avg. daily gain, lbs.	1.68	1.67	1.65	1.63	1.69	1.69	1.67	1.67	0.0
Days to 220 lbs.	169.2	170.0	174.2	172.9	170.5	170.6	171.1	171.3	0.1
Probe Backfat Data:									
No. gilts	51	49	48	50	53	53	148	156	
Backfat thickness, in.*	1.36	1.32	1.30	1.37	1.16	1.31	1.33	1.28	3.8
Feed Records:									
No. pens	6	6	6	6	6	7	18	19	
Feed/pig/day, lbs.	5.1	4.9	5.0	5.0	4.8	5.3	5.0	5.0	0.0
Lbs. feed/lbs. gain	3.09	2.95	3.07	3.08	2.93	3.20	3.04	3.06	—.7

[1] Includes the reciprocal crosses. Example: D-H includes all ½ Duroc: ½ Hampshire pigs regardless if sired by a Duroc or a Hampshire boar.
[2] First letter designates the breed of sire. Includes pigs farrowed by reciprocal breeds of dam.
*Difference between 2-breed and 3-breed cross is significant ($P<.05$).

Table 2. Carcass Cutout Data for 2-Breed and 3-Breed Cross Barrows from 1972 Spring Farrowing

	2-Breed Crosses[1]			3-Breed Crosses[2]			Overall		
	D-H	D-Y	H-Y	DxH-Y	HxD-Y	YxD-H	2-Breed Crosses	3-Breed Crosses	% Imprvmt. over 2-Breed
No. barrow carcasses	20	18	17	20	17	18	55	55	
Carcass length, in.	30.3	30.4	30.6	30.3	30.8	30.4	30.4	30.5	0.3
Carcass backfat, in.	1.17	1.30	1.27	1.29	1.13	1.32	1.25	1.25	0.0
Loin eye area, sq. in.	4.38	4.63	4.54	4.70	4.64	4.17	4.52	4.50	—.4
Lean cuts of live wt., %	40.9	41.2	41.4	40.7	42.0	39.5	41.2	40.7	—1.2
Ham — loin index	94.8	100.3	99.3	99.6	103.0	86.5	98.1	96.4	—1.7
Carcass quality scores:[3]									
Marbling score	3.9	5.2	3.6	4.8	4.0	4.3	4.2	4.3	2.4
Firmness score	4.9	5.8	4.8	5.8	4.8	5.1	5.2	5.2	0.0
Color score	4.6	5.3	4.7	4.6	4.8	4.8	4.9	4.7	—4.1

[1] Includes the reciprocal crosses. Example: D-H includes an equal number of DxH and HxD pigs.
[2] First letter designates sire breed. Approximately the same number of barrows were slaughtered from each reciprocal dam breeding group.
[3] Loin quality at 10th rib evaluated using a 7-point scoring system: 1=devoid of marbling, very soft and pale; 5=average marbling and firmness and pink color; 7=abundant marbling, very firm and very dark.

may be rather large differences in the maternal influence of the three pure breeds for feedlot performance and carcass traits.

Another important question is whether reciprocally produced crossbred females differ in their maternal influence for these traits and also the relative importance of the maternal heterosis of the crossbred dam. However, more data are needed before any definite conclusions can be made.

Swine Crossbreeding Results: 2-Breed Crosses vs. Purebreds

I. T. Omtvedt, R. K. Johnson, L. E. Walters
T. W. Williams and S. D. Welty

Story in Brief

The reproductive performance for 440 Duroc, Hampshire and Yorkshire dams, the feedlot performance for 941 pigs, and the carcass data on 190 slaughter pigs were used to evaluate the influence of using a boar of a different breed on purebred females. Yorkshire females had a higher reproductive failure rate than Durocs or Hampshires, and Hampshires had a lower ovulation rate than Durocs or Yorkshires. Productivity of Durocs and Hampshires was increased by mating them to a boar of a different breed, but crossbreeding had negligible influence on the productivity of Yorkshire females. However, the purebred Yorkshire litters were larger and heavier than crossbred litters produced by Durocs and Hampshires.

Overall, purebred sows with crossbred litters showed an advantage of 7.4 percent more pigs at farrowing, 16.1 percent more pigs at weaning,

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17.5 percent heavier litter weaning weights and 12.1 percent higher pre-weaning pig livability over purebred sows with purebred litters.

Crossbred pigs reached market weight 10 days earlier and consumed 5.7 percent more feed per day than purebreds. Differences in feed efficiency between purebreds and crossbreds were negligible, but purebred Yorkshire pigs tended to be most efficient.

Breed differences were noted in backfat thickness, lean yield and meat quality; but purebred performance tended to be a good predictor of crossbred performance. Hampshires had less backfat thickness and higher lean cut yield, but had lower muscle quality scores than the other two breeds. Hampshire-Yorkshire crosses revealed negative heterosis since they were fatter, had lower lean cut yields and lower muscle quality scores than the average for the purebreds making up this cross. When Durocs were used in the cross, there was a marked increase in quality over crosses which did not involve Durocs.

Introduction

Crossbreeding is widely used in the livestock industry to capitalize on the desirable characteristics of different breeds and to obtain increased performance in the crossbred individual over the average of the parent breeds making up the cross (heterosis). Although a high percentage of the hogs marketed in the United States are of crossbred origin, breeders do not have sufficient data available to know which crosses yield best results.

This study was initiated in 1969 at the Oklahoma Experiment Station to evaluate the overall combining ability of Durocs, Hampshires, and Yorkshires and to determine the relative amount of heterosis achieved for all economically important traits. The results presented in this paper deal with the first phase of the project where the influence of using a boar of a different breed on purebred gilts is evaluated.

Materials and Methods

The purebred seedstock herds for this project are maintained at Stillwater with the evaluation herds maintained at the Ft. Reno Experiment Station. An attempt is made to maintain a relatively broad genetic base in each of the seedstock herds and to keep inbreeding to a minimum. Two new unrelated boars are purchased for each herd each year, and three boars are kept over for another breeding season.

In the fall of 1969, the 3 purebred seedstock herds were formed by obtaining about 25 gilts and 5 boars for each herd. The initial breeding stock came from as many different lines of breeding as possible within each breed. From the purebred litters produced at Stillwater in 1970 spring, 54 gilts and 6 boars from each breed were selected after they completed a feeding test and taken to Ft. Reno for breeding in 1970 fall. Each boar was mated to 3 gilts of his own breed and to 3 gilts from each of the other two breeds.

Approximately 30 days after breeding, one gilt from each mating type for each boar was randomly selected to be slaughtered to evaluate ovulation rate and early embryo development. The other 2 gilts from each mating type for each boar were carried full term and permitted to farrow. During the first season this system resulted in 45 gilts slaughtered for reproductive tract studies and 88 gilts farrowed. This procedure was again repeated six months later with a new group of boars and gilts from the Stillwater herd, and 74 gilts were slaughtered one month after breeding and 87 were permitted to farrow.

Approximately one-half of the females farrowing during the second season were sows and their records were adjusted over all breed groups to a gilt equivalent basis with a least squares additive correction factor. Because of management problems in the fall 1971 farrowing season, excessive post-farrowing death losses occurred, and the females that farrowed in that season were remated in late winter to farrow in summer 1972. These sows were randomly mated in the same manner as described for the other seasons to a new group of young boars of each breed from Stillwater. No sows were slaughtered, and 69 litters from this season were included in the analyses. All pigs from these summer litters were sold after weaning.

All sows in this study farrowed in confinement and each sow and litter was penned separately until the pigs were weaned at 42 days of age. Pigs were given access to creep feed after the 21-day weights were obtained. Two weeks after weaning, the pigs were moved to the confinement finishing barn and allotted by breed in groups of about 16 pigs per pen. The pigs were given one week to get adjusted to their new surroundings before being weighed on test.

All pigs were self-fed a 16 percent crude protein ration until they reached 220 lbs. Pigs were weighed off test on a weekly basis as they weighed 220 lbs., and all gilts were probed for backfat thickness at that time. The postweaning feeding tests included the performance on a total of 941 pigs and feed records on 63 pens. Probe backfat measurements were taken on 479 gilts. About 10 barrows per breed group were taken to the University Meat Laboratory and slaughtered for carcass cutout and muscle quality data. A total of 190 carcasses were evaluated in this study.

Results

Reproductive Efficiency

The breeding performance for the 440 females selected for the breeding herd is summarized in Table 1. In this project, estrus was detected with the assistance of a teaser boar, and hand mating was used in all seasons. Gilts were between 210 and 270 days of age at the beginning of the breeding season, and the breeding season was long enough to permit problem breeders to have at least 3 complete estrous cycles. Overall, 59 of the 440 females (13.4 percent) failed to conceive. The percentage of failures for Durocs, Hampshires, and Yorkshires were 10.1, 6.8 and 23.4 percent, respectively, with Yorkshires having a significantly higher failure-rate than the other two breeds.

Since the reproductive failures among Yorkshires were also greater than the failure-rates for Duroc and Hampshire sows, the observed breed differences could not be due to differences in sexual maturity at breeding. Part of the difference could be attributed to the fact that the visual signs of estrus are less vivid among Yorkshire females, and therefore, a higher percentage were not observed in heat when they actually would have accepted a boar under a natural mating system.

Table 1. Reproductive Efficiency and Ovulation Rate by Breed of Sow

	Breed of Dam		
	Duroc	Hampshire	Yorkshire
Reproductive Efficiency:			
Gilt Data:			
No. selected for breeding	100	100	101
No. pregnant at end of season	93	94	77
No. failing to reproduce	7	6	24
Failure rate, %*	7.0	6.0	23.8
Sow Data:			
No. selected for breeding	49	46	44
No. sows that farrowed	41	42	34
No. failing to farrow	8	4	10
Failure rate, %*	16.3	8.7	22.7
Overall:			
Total no. selected for breeding	149	146	145
No. pregnant at end of season	134	136	111
No. failing to reproduce	15	10	34
Failure rate, %*	10.1	6.8	23.4
Ovulation Rate for Gilts Slaughtered:			
No. gilts slaughtered	43	40	36
No. corpora lutea per gilt*	13.8	12.1	13.8

*Indicates that breed difference was significant ($P < .05$).

Ovulation Rates and Early Embryo Development

As shown in Table 1, Duroc and Yorkshire gilts ovulated more eggs than Hampshire gilts. The embryo data presented in Table 2 shows that purebred Duroc and Hampshire gilts tended to have more developing embryos when mated to a boar of a different breed, but the number of developing embryos for Yorkshire gilts was about the same whether they were carrying purebred or crossbred embryos. Overall, gilts with crossbred litters had a higher proportion of the eggs ovulated represented as live embryos when slaughtered at 30 days postbreeding, but this advantage was primarily due to the higher percentages obtained for crossbred litters in Durocs and Hampshires.

These data show no advantage for using a boar of a different breed on Yorkshires but considerable advantage for the other two breeds. Crossbred embryos were not consistently larger than purebred embryos in this study, but Hampshire and Duroc gilts tended to have larger embryos than Yorkshire gilts.

Litter Production Records

The litter records are summarized in Table 2. Purebred dams of all breeds with crossbred litters farrowed and raised more pigs per litter than did purebred dams with purebred litters resulting in an overall increase in litter size of 0.7 pigs at farrowing and 1.0 pig at weaning. This advantage was most pronounced among Duroc dams at farrowing and both Duroc and Hampshire dams showed a definite advantage for number of pigs raised when the litter was crossbred. Yorkshire females weaned the largest litters and using a boar of a different breed did not have any marked effect on their productivity. The greatest increase in livability (19 percent) due to crossing was noted among Hampshire dams with Durocs revealing a somewhat smaller increase (5.3 percent), and Yorkshires showing virtually no difference between purebred and crossbred litters.

Breed of dam differences for litter traits through weaning were apparent. Both Duroc and Yorkshire dams farrowed larger litters than Hampshires while at 42 days Yorkshire dams had larger litters than either Duroc or Hampshire dams, while the 0.4 pig per litter difference in litter size of Duroc and Hampshire dams at 42 days was not significant. Overall, Yorkshire dams raised 13 percent more of their pigs from birth to weaning.

Pigs from Yorkshire dams weighed less at birth than those from Duroc and Hampshire dams. However at 21 days of age, pigs from Yorkshire dams were the heaviest even though they were also from larger litters. This suggests that Yorkshire dams not only were better mothers

Table 2. Reproductive Performance of Purebred Sows with Crossbred Litters Compared to Those with Purebred Litters

	Duroc Sows		Hamp Sows		York Sows		Overall		% Improvement
	Pure	Cross	Pure	Cross	Pure	Cross	Pure	Cross	over Purebreds
Early Embryo Development:									
No. gilts slaughtered	13	30	14	26	12	24	39	80	
No. embryo per gilt*	10.6	11.1	8.6	9.9	11.4	11.3	10.2	10.7	4.9
% embryos of eggs ovulated*	74.2	81.9	74.5	82.3	83.9	83.1	77.6	82.5	6.3
Embryo size, mm.	24.5	25.2	26.0	25.3	23.3	24.4	24.6	25.0	1.6
Litter Records:									
No. litters	31	53	32	58	23	47	86	158	
No. pigs farrowed/litter*	9.5	10.6	8.9	9.4	10.2	10.7	9.5	10.2	7.4
Avg. pig birth wt., lb.	2.9	2.8	2.7	2.8	2.4	2.4	2.7	2.7	0
Avg. pig 21-day wt., lb.	9.6	10.2	10.4	10.7	10.8	10.5	10.3	10.5	1.9
Avg. pig 42-day wt., lb.	22.9	23.3	21.8	23.2	24.3	23.4	23.0	23.3	1.3
No. pigs raised/litter*	5.7	7.0	5.2	6.7	7.7	8.0	6.2	7.2	16.1
Litter 42-day wt., lb.*	130	163	113	155	187	187	143	168	17.5
% survival*	61.0	66.3	54.6	73.6	77.4	76.5	64.3	72.1	12.1

*Indicates that difference observed between purebreds and crossbreds was significant ($P < .05$).

in terms of keeping their pigs alive but also provided a larger supply of milk per pig than did Duroc and Hampshire dams. The fact that the differences between 42-day pig weights were small suggests that the creep feed being fed from 21 to 42 days of age tended to compensate for milk production and perhaps masks breed differences in maternal ability from 21 to 42 days.

Although the differences in number of embryos 30-days postbreeding among purebred litters and crossbred litters for each breed of dam were not significant, they were used in the same direction and of approximately the same magnitude for each breed of dam as were the traits from birth to weaning. This lends further support to the idea that dams of these three breeds will exhibit a defferent response to crossbreeding in litter size.

None of the differences between average pig weight per litter for purebreds and crossbreds in this study were significant and all did not favor crossbreds. On the average, crossbred pigs and purebred pigs weighed the same at farrowing, but crossbred pigs averaged 0.3 lb. heavier than purebreds at weaning. This represents a relatively small increase of 1.34 percent in average pig weight per litter for crossbred litters over purebred litters. However, crossbred litters weighed 25 lbs. more than purebred litters at weaning yielding an increase of 17.5 percent.

These data suggest some response to crossbreeding in early embryo development; however, the primary response to crossbreeding appears to be in ltiter size at birth and weaning and a greater survival rate for crossbred pigs than for purebred pigs. It appears that this response is due primarily to an increased livability throughout gestation and from birth to weaning in crossbred litters produced by Duroc and Hampshire dams with little, if any, difference in livability between purebred and crossbred litters from Yorkshire dams. Other factors such as increased fertilization rate or implantation rate when using a boar of another breed on Duroc and Hampshire dams may also be important; however, these data are insufficient to determine the reason for the differential response of breeds.

Growth Rate and Feed Efficiency

The feedlot results are summarized in Table 3. Crossbred pigs gained 0.14 lb. per day faster than purebreds during the postweaning period and reached 220 lbs. in average of 10 days less time. In all cases the crossbred pigs gained significantly faster than the average of the purebreds making up the cross (this is heterosis). Purebred Durocs tended to gain faster than purebred Hampshires and Yorkshires, but none of the differences were significant except for Durocs reaching 220 lbs. at an earlier age than Hampshires. When Durocs were involved in the cross, the pigs tended to grow faster than when Durocs were not used in the cross.

Crossbred pigs consumed an average of 5.7 percent more feed per day than purebreds. Purebred Yorkshires had the lowest daily consumption and the most desirable feed efficiency. Overall, there was essentially no difference in the feed efficiency of purebreds and crossbreds.

Probe Backfat Thickness of Gilts

Although there was no marked difference between the fatness of purebreds and crossbreds, some differences between breed groups were noticed. Durocs were fatter than Hampshires and Yorkshires. Duroc-Hampshire crossbreds had 0.05 in. less backfat than the average of the purebred Durocs and Hampshires. Crosses involving Durocs tended to be fatter than when Durocs were not used in the cross.

Carcass Tracts

The data for the 190 carcasses evaluated are shown in Table 4. Rather large differences among purebreds were noted, but the differences between purebreds and crossbreds tended to be relatively small. Durocs were shorter than Hampshires and Yorkshires, however Hampshires had less backfat than Durocs and Yorkshires and exceeded them in loin eye area and yield of lean cuts. There was little difference between purebred Durocs and Yorkshires for these traits.

Each of the quality scores of marbling, firmness, and color ranked in the order of Durocs, Yorkshires, and Hampshires. Differences between Durocs and Hampshires were significant for all three traits while the differences between Durocs and Yorkshires were significant for marbling and firmness scores. Yorkshires also had higher firmness and color scores than Hampshires.

In general, the average of the purebreds making up the cross was a good predictor of the crossbred carcass merit. However, Duroc-Yorkshire crosses were longer than the average of the breeds making up that cross, and Hampshire-Yorkshire crosses tended to be fatter and have a lower lean cut yield than the average for purebred Hampshires and Yorkshires.

All crosses involving Durocs resulted in rather large positive heterosis for marbling and firmness scores; however, there was negative heterosis for these traits in Hampshire-Yorkshire crosses. There was considerable variation among crosses in the amount of heterosis expressed for color score; however, the difference between crossbreds, and purebreds was significant only in the Hampshire-Yorkshire cross.

Table 3. Postweaning Performance and Probe Backfat Data for Purebreds Compared to 2-Breed Cross Pigs.

	Purebreds			2-Breed Crosses			Overall		% Improvement over Purebreds
	Durocs (D)	Hamps (H)	Yorks (Y)	DxH	DxY	HxY	Purebreds	Crossbreds	
Growth Rate:									
No. pigs	85	65	79	234	270	208	229	712	
Daily gain, lb.*	1.48	1.45	1.44	1.61	1.62	1.58	1.46	1.60	10.2
Days to 220 lbs.*	187.0	192.7	189.1	179.7	178.2	181.0	189.6	179.6	5.3
Feed Records:									
No. pens	7	7	9	12	15	13	23	40	
Feed/pig/day, lbs.*	5.23	4.90	4.59	5.46	5.08	4.99	4.90	5.18	5.7
Lbs. feed/lb. gain	3.34	3.27	3.11	3.33	3.15	3.17	3.24	3.22	0.6
Probe Backfat Data:									
No. gilts	50	38	53	111	130	97	141	338	
Backfat thickness, in.	1.38	1.16	1.19	1.22	1.25	1.20	1.24	1.22	1.6

*Indicates that difference between purebreds and crossbreds was significant ($P < .05$).

Table 4. Carcass Cutout Data for Purebreds Compared to 2-Breed Crosses

	Purebreds			2-Breed Crosses			Overall		% Improvement over Purebreds
	Durocs (D)	Hamps (H)	Yorks (Y)	DxH	DxY	HxY	Purebreds	Crossbreds	
No. carcasses	22	23	22	40	41	42	67	123	
Carcass length, in.	30.1	30.7	30.8	30.5	30.8	30.8	30.5	30.7	0.6
Carcass backfat, in.	1.26	1.06	1.24	1.20	1.20	1.22	1.19	1.21	—1.9
Loin eye area, sq. in.	4.84	5.22	4.70	4.96	4.77	4.86	4.92	4.86	—1.2
% lean cuts of carcass wt.	54.9	58.5	56.1	56.5	56.0	56.4	56.5	56.3	—0.4
Ham-loin index	95.6	108.4	97.3	101.1	97.7	99.1	100.6	99.3	—1.3
Carcass quality:[1]									
Marbling score*	5.6	3.1	3.7	5.5	5.3	2.8	4.1	4.6	10.7
Firmness score	5.9	3.8	4.7	5.6	5.6	3.7	4.8	5.0	4.4
Color score	5.3	4.4	5.1	5.2	5.2	4.3	4.9	4.9	0

[1] Loin quality at 10th rib was evaluated using a 7-point scoring system; 1=devoid of marbling, very soft and pale; 5=average marbling and firmness and dark pink color; 7=abundant marbling, very firm and very dark.
*Indicates that differences observed between purebreds and crossbreds was significant ($P < .05$).

These data tend to support the conclusion that there is little heterosis for carcass traits and that the average crossbred performance for most traits can be predicted quite well from the average of the purebreds which made up the cross. There appears to be considerable heterosis expressed for carcass quality; however, the amount and direction seem to be dependent on the specific cross involved.

With the exception of carcass length and the quality scores, none of the differences between the crossbred averages were significant. Duroc-Hampshire crosses were shorter than both Duroc-Yorkshire crosses and Hampshire-Yorkshire crosses. When Durocs were used in the cross, there was a marked increase in quality score over crosses which did not involve Durocs.

Additional studies involving greater numbers and more sire groups are needed before any conclusions can be made regarding differences between reciprocal crosses. The limited data available indicates that there may be some real differences in pig performance and carcass traits for pigs of the same breed composition depending upon which breed serves as the sire and which breed serves as the dam. Additional research is underway at the present time to further evaluate this difference.

Reproductive Performance of Purebred Gilts with 2-Breed Cross Litters Compared to Crossbred Gilts with 3-Breed Cross Litters

R. K. Johnson, I. T. Omtvedt, T. W. Williams and S. D. Welty

Story in Brief

The productivity of 379 purebred and 2-breed cross gilts of Duroc, Hampshire and Yorkshire breeding was evaluated in this study. Purebred gilts with 2-breed cross litters were compared to crossbred gilts with 3-breed cross litters to determine the relative advantage of using crossbred sows and to compare the performance of 2-breed and 3-breed cross pigs. One month after breeding, 193 gilts (87 purebred and 106 crossbred) were slaughtered and evaluated for ovulation rate and early embryo development. The other 186 gilts (90 purebred and 96 crossbred) produced litters during the 1972 spring and fall farrowing seasons at Ft. Reno.

Although differences were not large, the ovulation rates tended to favor the purebred gilts. However, crossbred gilts had 7 percent more of their corpora lutea represented as viable embryos at the end of the first month of pregnancy. The crossbred gilts had 0.55 more embryos and farrowed 0.4 more pigs per litter than purebred gilts, although these differences were not significant. The embryo size and pig birth weights for 2-breed and 3-breed crosses were similar.

The survival rate from birth to weaning of 3-breed cross pigs raised by crossbred dams was 84.5 percent as compared to 78.7 percent for 2-breed cross pigs raised by purebred dams. This resulted in the 3-breed cross litters being significantly larger (8.3 vs. 7.4 pigs per litter) and heavier (193 vs. 174 lbs.) at weaning even though there was virtually no difference between the weights of 2-breed and 3-breed cross pigs at weaning.

Introduction

Crossbreeding studies with swine have shown increases in litter size at birth and greater survival rate for crossbred pigs from birth to weaning. Crossbred females are recommended in most commercial breeding programs in order to combine the desirable qualities of different breeds and to take advantage of the heterosis exhibited by utilizing a crossbred sow in addition to that obtained in the crossbred pig. However, information on the relative advantage of crossbred females over straight bred

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females, and which specific crossing sequences should be made to obtain maximum performance from crossing is unavailable.

The results presented in this paper deal with the second phase of the Oklahoma swine crossbreeding study initiated in 1969. Purebred and 2-breed cross gilts of Duroc, Hampshire and Yorkshire breeding were mated to boars of each of the other breeds to produce 2-breed and 3-breed cross litters. Data are presented for early embryo development and for productivity at farrowing and weaning.

Experimental Procedure

The 379 gilts for this study were selected at random from the purebred and 2-breed cross litters produced in the 1971 spring and fall farrowing seasons at Ft. Reno. Approximately six purebred boars of each breed that were produced in the Stillwater seedstock herds were used to produce the 2-breed and 3-breed cross litters each season. This study includes the data from 193 gilts slaughtered 30-days postbreeding and the litter records for 186 gilts farrowing in the 1972 spring and fall seasons.

The basic mating scheme used each season was to mate each boar to approximately 12 gilts (3 each of each breed type not represented in the boar). At the time of breeding, two gilts from each mating type for each boar were randomly selected to be carried full term to farrowing and the remaining gilts were designated for slaughter 30-days postbreeding to evaluate ovulation rates and early embryo development. This system resulted in 78 gilts slaughtered and 98 farrowed in 1972 spring and 115 gilts slaughtered and 88 farrowed in 1972 fall.

This study includes ovulation rates and early embryo development for 87 purebred gilts with 2-breed cross litters and 106 crossbred gilts with 3-breed cross litters. The litter records from farrowing to weaning include 90 two-breed and 96 three-breed cross litters. The number of gilts slaughtered and farrowed for each mating type are shown in Table 1. All gilts were farrowed in confinement and each sow and litter was penned separately until the pigs were weaned at 42 days of age. Individual pig weights were obtained at birth, 21 and 42 days, and the pigs were given free access to creep feed after the 21 day weights were obtained.

Results

Data for ovulation rate, early embryo development and sow productivity at farrowing and weaning are presented in Table 1.

These results suggest that crossbreeding does not increase ovulation rate. Overall, the purebred gilts had an average of 0.5 more corpora lutea per gilt than the crossbred gilts; however, none of the differences in ovulation rates were significant. In all cases the ovulation rates for the

Table 1. Reproductive Performance of Purebred Gilts with 2-Breed Cross Litters Compared to Crossbred Gilts with 3-Breed Cross Litters

	Breed of Dam Producing 2-Breed Litters			Breed of Dam Producing 3-Breed Litters			Overall		% Improvement of Crossbred
	Duroc (D)	Hamp (H)	York (Y)	D-H	D-Y	H-Y	Purebred Dams	Crossbred Dams	Dams Over Purebred Dams
Early Embryo Development:									
No. gilts slaughtered	31	31	25	33	38	35	87	106	
No. corpora lutea per gilt	13.4	13.3	13.9	13.1	13.5	12.5	13.5	13.0	—3.7
No. embryos per gilt	10.5	8.8	10.8	10.8	10.6	10.4	10.0	10.6	6.0
% embryos of corpora lutea	78.9	66.3	77.9	82.6	78.6	83.1	74.4	81.4	9.4
Embryo size, mm.	28.0	27.6	27.9	28.2	27.8	28.1	27.8	28.0	0.7
Litter Records:									
No. litters	34	27	29	32	32	32	90	96	
No. pigs farrowed per litter	8.9	9.6	10.1	9.7	10.3	9.7	9.5	9.9	4.2
Avg. pig birth wt., lbs.	2.8	2.6	2.4	2.8	2.6	2.4	2.6	2.6	0.0
Avg. pig 42-day wt., lbs.	23.3	23.8	23.1	24.1	23.2	22.9	23.4	23.4	0.0
No. pigs weaned per litter*	6.9	7.7	7.7	8.1	8.0	8.6	7.4	8.2	10.8
Litter 42-day wt., lbs.	161.4	183.4	177.5	195.4	185.4	197.7	174.1	193.0	10.9
Survival rate, %	77.5	79.4	79.1	85.4	79.8	88.4	78.7	84.5	7.5

*Indicates that differences observed between 2-breed and 3-breed crosses were significant ($P<.05$).

2-breed cross gilts were lower than that for the average of the purebred gilts making up the cross. The Hamp-York crossbred gilts had 1.0 fewer corpora lutea per gilt than the average of purebred Hamps and Yorks.

With the exception of purebred Hampshire gilts, there was very little difference between purebred and crossbred gilts in the number of developing embryos per gilt after one month pregnancy. Purebred Hampshire gilts had significantly fewer embryos per gilt than all other types of gilts and as a result crossbred gilts had 5.5 percent more embryos 30-days after breeding than did purebred gilts, although this difference was not significant. The largest numbers of developing embryos were observed for purebred Yorkshires and Duroc-Hamp crossbred gilts. The Duroc-Hamp crossbred gilts averaged 1.2 more embryos than the average for the two parent breeds making up the cross.

There was a tendency for the crossbred gilts to have a higher percentage of the ova shed to be represented as viable embryos at the end of the first month of pregnancy. There was no marked difference in embryo size between 2-breed and 3-breed cross litters.

Crossbred gilts apparently provide a more desirable uterine environment than purebred gilts, or the 2-breed cross embryos are more viable than the 2-breed cross embryos, since a higher percentage of the ovulations for crossbred gilts with 3-breed cross litters are represented as live pigs at farrowing. Crossbred dams with 3-breed cross litters averaged 0.4 more pigs per litter at farrowing than purebred dams with 2-breed cross litters, but the differences in litter size at birth were not significant. Litter size at weaning was about 11 percent larger for crossbred dams compared to purebred dams and the increase in survival rate to weaning for 3-breed cross litters was 7.5 percent larger than for 2-breed cross litters.

Although none of the individual comparisons of the means for a crossbred dam and the average of the two purebreds which made up the cross were significant for number of pigs per litter at weaning, in all cases the crossbred gilts weaned larger litters. Overall, crossbred dams raised 0.8 more pigs per litter and their litters weighed 19 lbs. more than purebred dams at weaning.

Two-breed and 3-breed cross pigs weighed nearly the same at birth. However, 2-breed cross pigs from Duroc dams were significantly heavier (0.4 lbs.) at birth than those from Yorkshire dams and 3-breed cross pigs from Duroc-Hampshire dams were significantly heavier at birth than those from the other crossbred sows. At weaning there was no difference in the average pig weight of 3-breed and 2-breed cross pigs nor were any of the comparisons among individual means significant.

These data indicate that purebred and 2-breed cross gilts have similar ovulation rates, but the 3-breed cross embryos from crossbred gilts have a greater early embryonic survival rate than 2-breed cross embryos. Although crossbred dams tended to farrow somewhat larger litters than purebred dams, the largest increase in performance from using a crossbred dam came from increased survival rate from birth to weaning. The 3-breed cross litters were approximately 11 percent larger and heavier than the 2-breed cross litters in this study. No marked differences in pig weights at birth and weaning between 2-breed and 3-breed cross litters were observed.

Influence of the Litter in which a Gilt is Raised and Her Own Performance on Her Subsequent Reproductive Performance

L. D. Young and I. T. Omtvedt

Story in Brief

This study was initiated to determine what possible influence the size and weight of the litter in which the gilt is raised and her own size, growth rate and fatness will have on the size of her first litter. The records from a total of 176 first-litter gilts from the Fort Reno Experiment station were studied.

Although most traits studied were not closely associated with the size of the gilt's first litter, some interesting trends were noted. Gilts with heavier birth weights farrowed larger litters and an increase of 1 lb. in birth weight resulted in an increase in litter size of 0.75 pigs. In Duroc and Beltsville No. 1 gilts, there was a tendency for gilts from larger litters to farrow fewer pigs, but this trend was not noticed among the crossbred gilts. Overall, the number of pigs raised in the litter from which the gilt came was not closely associated with the number of pigs she farrowed.

Duroc and Beltsville No. 1 gilts with faster gains, thus reaching 200 lbs. at an earlier age, tended to farrow larger litters. The gilt's degree of fatness was not consistently associated with the size of her first litter.

Most of the traits evaluated did not have any marked influence on the size of a gilt's first litter, but these data do indicate that swine producers can not justify placing much selection emphasis on the number of pigs farrowed in the litter from which gilts are selected.

Introduction

Litter size is of tremendous economic importance in swine, and it is also very important in swine improvement programs because the size of the litter is what limits the amount of selection possible. Litter size is lowly heritable and, therefore, is greatly affected by environment. One of these environmental factors may be the size of the litter the gilt was born and raised in. Some research has indicated that gilts selected from larger than average litters tend to have smaller than average first litters.

This study was initiated to determine how her birth weight, her weaning weight, her postweaning growth rate, her fatness, and the number and weight of the pigs in the litter from which she was selected will influence on the size of a gilt's first litter.

Materials and Methods

This study involved the records of 176 first litter gilts that were born in the spring and fall of 1967 and 1968 at the Fort Reno Experiment Station. The gilts consisted of 60 crossbreds, 55 Beltsville No. 1, and 61 Durocs that farrowed their first litters at one year of age.

The gilts were weaned at approximately 6 weeks of age and moved to a confinement feeding facility at about 8 weeks of age. They were self-fed until they reached 200 lbs. at which time they were weighed off test and probe backfat measurements were taken on each gilt. The Beltsville gilts were bred to Duroc boars, the Duroc gilts were bred to Beltsville boars, and the crossbred gilts were bred to unrelated crossbred boars so that all three groups of gilts produced crossbred litters.

Results and Discussion

The means for the traits evaluated in this study for the three breeds are shown in Table 1.

The correlations of the various traits with the number of pigs in the gilt's first litter are given in Table 2. None of the traits evaluated were closely related to the size of her first litter. There was a tendency for the size of the litter at birth that the gilt came from to be adversely

Table 1. Means for the Crossbred, Beltsville No. 1, and Duroc Gilts Used in the Study

	Crossbreds	Beltsville No. 1	Duroc	Overall Means	Overall Standard Deviation
Number of Gilts	60	55	61		
Litter in which Gilt was Raised:					
No. of pigs farrowed	10.2	10.9	11.6	10.9	2.3
Litter birth wt., lbs.	28.8	32.9	35.9	32.5	7.7
No. of pigs weaned	8.6	8.3	9.2	8.7	2.3
Litter weaning wt., lbs.	239.1	262.7	251.5	250.7	65.4
Gilt's Own Performance:					
Birth wt., lbs.	2.9	3.2	3.2	3.1	0.6
42-day wt., lbs.	29.5	32.6	27.9	29.9	5.4
Days at 200 lbs.	157.8	157.4	159.3	158.2	12.0
Probe at 200 lbs., in.	1.5	1.3	1.4	1.4	0.2
Gilt's First Litter:					
No. of pigs farrowed	9.8	8.9	10.4	9.7	2.9
No. of pigs weaned	7.9	6.2	7.5	7.2	2.7

Table 2. Correlations Between the Number of Pigs Farrowed in a Gilt's First Litter and Various Production Traits by Breed and Pooled Within Breed

	Crossbred	Beltsville No. 1	Duroc	Pooled Within Breed
Litter In Which Gilt Was Raised:				
No. of pigs farrowed	.04	—.17	—.21	—.13
Litter birth weight	.05	.04	—.16	—.03
Litter birth weight	.05	.05	—.08	.01
Litter weaning weight	—.05	.15	—.04	.03
Gilt's Own Performance:				
Birth weight	.01	.30[1]	.14	.16[1]
42-day weight	—.14	.30[1]	.05	.10
Age at 200 lbs.	.08	—.20	—.20	—.13
Probe at 200 lbs.	—.17	—.09	.10	—.04

[1] Significantly different from zero at .05 level.

related to the size of her first litter (r = _ .13). Gilts from larger litters tended to farrow smaller litters than gilts selected from smaller litters. An increase of one pig in the size of the litter she came from resulted in a decrease of 0.16 pigs in her first litter. However, the size of the litter at 42 days that she came from was not associated with the size of her first litter (r = 0.01). This may be due to the larger losses that normally occur in the larger litters prior to weaning.

Gilts that were heavier at birth and at weaning tended to have larger litters than gilts that were lighter at birth and weaning. The correlation between the gilt's own birth weight and size of her first litter was 0.16. The correlation between her 42-day weight and the size of her first litter was not significant but followed the same trend as noted for birth weight ($r = 0.10$). In this study, each increase of 1 lb. in the gilt's birth weight was accompanied by an increase of 0.75 pigs in her first litter while each 10 lbs. increase in her 42-day weight resulted in an increase of 0.53 pigs in her first litter.

There was a tendency for gilts that reached 200 lbs. at an earlier age to farrow larger litters, but age at 200 lbs. actually accounted for less than 2 percent of the variation in litter size. A decrease of 10 days in age at 200 lbs. resulted in an increase in litter size of 0.30 pigs. In the crossbred gilts, backfat thickness was negatively correlated with size of first litter, but this trend was not noticed in the other two breed groups. Overall, backfat thickness was not associated with litter size in this study.

These results indicate that the size of the litter the gilt was selected from, her growth rate, or her backfat thickness will not greatly influence the size of her first litter. Since it is well established that litter size is lowly heritable and that most of the variation in litter size is due to environmental factors, the results obtained in this study clearly emphasize the point that swine producers cannot justify placing much selection pressure on litter size when selecting gilts for the breeding herd.

Treatment of Anestrous Gilts With Estradiol Valerate to Induce Estrus

R. P. Wettemann, I. T. Omtvedt and T. W. Williams

Story in Brief

A group of 24 anestrous gilts were injected with either 0.25 or 1.0 mg. of estradiol valerate in an attempt to initiate estrus and ovulation. Fourteen (87.5 percent) of the 16 treated gilts exhibited estrus within eight days after treatment, whereas only two of the eight control gilts (25 percent) were in estrus during that period.

Gilts given the high dose of estradiol tended to exhibit estrus sooner and remain in estrus longer than gilts on the low dose. Prior to treatment, plasma progesterone averaged less than 0.5 ng/ml and increased to greater than 10 ng/ml by 14 days after treatment in 10 of the 14 gilts in which estrus was induced. These data suggest that ovulation occurred at the induced estrus.

Introduction

Although some gilts are of breeding size and age, they do not exhibit estrus. This anestrous condition may be caused by a lack of ovarian follicular growth so estrogen is not synthesized and ovulating hormone is not released from the anterior pituitary. Studies with cattle and sheep suggest that injection of estrogen will cause release of ovulating hormone as well as the induction of estrus.

The purpose of this study was to determine if injection of estradiol valerate would induce estrus in anestrous gilts and to determine if ovulation occurs at the induced estrus.

Materials and Methods

A group of 24 gilts of Duroc, Hampshire and Yorkshire breeding in the Fort Reno swine breeding herd were used in this study. The gilts averaged 270 lbs. and were at least 8.5 months of age. These gilts had not exhibited estrus prior to being allotted to this study. Gilts were randomly divided into three treatment groups and injected subcutaneously with 1 ml of corn oil (control), 0.25 mg of estradiol valerate in 1 ml of corn oil or 1.0 mg of estradiol valerate in 1 ml of corn oil.

Blood samples were collected from all gilts just prior to treatment and at 14 days after treatment by puncture of the anterior vena cava and plasma progesterone was quantified by radioimmunoassay. Gilts were checked for estrus daily and were inseminated at the second estrus after treatment. The gilts were slaughtered 57 days after treatment and ovarian activity and pregnancy were determined.

Results and Discussion

Injection of either the low (0.25 mg) or high (1.0 mg) dose of estradiol valerate induced estrus in 7 of the 8 gilts within 8 days (Table 1). During the same period only 2 of the control gilts exhibited estrus. Gilts given the high dose of estradiol were in estrus sooner (2.6 vs. 4.1 days after treatment) and remained in estrus longer (3.4 vs. 2.6 days) than gilts on the low dose.

Five of the gilts in the low group returned to estrus within 18 to 24 days after the first estrus but only two gilts on the high group returned during this period. It appears the injection of 0.25 mg. of estradiol initiated normal estrous cycles. All gilts bred at the second estrus after treatment conceived so the percentage of the treated gilts pregnant was slightly greater for those given the low level of estradiol.

Prior to treatment, all gilts had less than 0.5 ng of progesterone per ml. of blood (Table 2). These results suggest that the ovaries were inactive. It is assumed that if corpora lutea (CL) were present, they would secrete greater than 1 ng/ml of progesterone during at least 70 percent of the estrus cycle. At 14 days after treatment, plasma progesterone was greater than 10 ng/ml in 10 of the 14 gilts in which estrus was induced. This suggests that ovulation occurred in 71 percent of the induced estrus.

When slaughtered at 57 days after treatment, 62, 37 and 62 percent of the gilts on control, 0.25 mg of estradiol and 1.0 mg of estradiol,

Table 1. Reproductive Performance of Gilts After Treatment with Estradiol Valerate

Criteria	Treatment		
	Control	0.25 mg E.V.[1]	1.0 mg E.V.
No. gilts per treatment	8	8	8
No. gilts in estrus by 8 days after treatment	2	7	7
Duration of first estrus, days	2.0	2.6	3.4
No. gilts in estrus on days 18 to 24 after first estrus	2	5	2
No. gilts bred at second normal estrus	3	5	3
No. gilts pregnant	3	5	3
Percent of treated gilts pregnant at slaughter	38	62	38

[1] Estradiol valerate (0.25 or 1.0 mg) was injected subcutaneously in one ml of corn oil.

Table 2. Endocrine and Ovarian Activity of Anestrous Gilts Before and After Treatment with Estradiol Valerate

Criteria	Treatment		
	Control	0.25 mg E.V.[1]	1.0 mg E.V.
No. gilts per treatment	8	8	8
Plasma progesterone before treatment, ng/ml	0.5	0.5	0.5
No. gilts with 10 ng/ml progesterone at 14 days after treatment	3	5	5
Mean plasma progesterone in gilts that had functional CL, ng/ml	28.5	24.8	16.6
Gilts with inactive ovaries at 57 days after treatment, %	62	38	62

[1] Estradiol valerate (0.25 or 1.0 mg) was injected subcutaneously in one ml of corn oil.

respectively, had inactive ovaries. None of the ovaries appeared pathologic. All gilts on the low dose of estradiol that ovulated at the induced estrus started to cycle and were pregnant at slaughter, but few of the ovulating gilts on the high dose continued to cycle. There appears to be a difference in the duration of estrus and the ovulatory response due to dose of estradiol.

Incidence and Transmission of Bordetella Infections in Swine

Charles V. Maxwell, R. E. Corstvet and I. T. Omtvedt

Story in Brief

A survey of the incidence of *Bordetella bronchiseptica* was made in two Oklahoma State University swine herds. Approximately 9.7 percent of the sows in herd 1 were positive and only one positive sow was observed in herd 2. The repeatability of positive cultures in positive sows was poor.

In a second study, no distinct differences were observed in the bacterial populations between pigs with early symptoms of atrophic rhinitis and pigs not showing early symptoms of the disease. Pigs exhibiting early symptoms of atrophic rhinitis, however, were found to have a much higher incidence and degree of turbinate atrophy at slaughter. All isolates of *Bordetella bronchiseptica* found in the OSU swine herds were resistant to sulfonamides.

Introduction

The cause of infectious atrophic rhinitis has been under active investigation for well over a century. During this time it was established that inoculation of very young pigs with turbinate lesion material would result in the transmission of atrophic rhinitis. This has led most workers to accept atrophic rhinitis as an infectious disease. The underdevelopment of the nasal bones appears to be due to a failure in bone growth associated with infection within the nasal cavity itself. Experiments have shown that several species of bacteria are possibly involved in causing atrophic rhinitis, but results to date suggest that *Bordetella bronchiseptict* is probably the bacteria most often responsible.

The extent of atrophic rhinitis in the swine population is difficult to determine as relatively few surveys have been made. Estimates of the incidence of atrophic rhinitis by examination of nasal turbinates has ranged from 5 to 40 percent of the pigs examined. The largest survey of over 1600 swine slaughtered from 1962 to 1969 indicated an incidence of about 25 percent.

Bordetella bronchiseptica has been found to be widely distributed among the swine population. In a recent survey, *B. bronchiseptica* was found in the nasal cavity of 54 percent of 87 Iowa purebred swine herds. It would appear that the incidence of *B. bronchiseptica* is also widespread in certain animal populations. An incidence of *B. bronchiseptica* has been observed in the rat, skunk, rabbit, opossum, fox, raccoon, dog and cat.

The fact that *B. bronchiseptica* is so widespread among a number of animal species suggests that this organism may be difficult to control. This difficulty is possibly reflected by the fact that 60 percent of the herds which failed to pass the SPF slaughter check failed as a result of turbinate atrophy. Not all isolates, however, are capable of producing turbinate atrophy. Results in one study indicated that four isolates of swine origin, an isolate of rabbit origin and an isolate of cat origin caused mild to moderate turbinate atrophy in 22 of 24 pigs. An isolate of rat origin caused mild turbinate atrophy in one of four pigs and an isolate of dog origin caused no turbinate atrophy.

Since a dagree of turbinate atrophy has been observed in the Oklahoma State University swine herds, studies were undertaken to determine the incidence of *B. bronchiseptica* in two of the University swine herds through recently developed techniques involving nasal swabs and cultures of the organism.

Phase I

All sows and gilts in the teaching herd and all sows in the animal breeding herd were used in the initial phase of this study which was conducted between October, 1971 and August, 1972. Standard procedures for swabbing and culturing for *B. bronchiseptica* were used. Sows in the teaching herd were swabbed from two to seven times each and sows in the animal breeding herd were swabbed twice. Gilts were swabbed once.

Results of the initial survey (Table 1) indicated a distinct herd difference in the incidence of *B. bronchiseptica*. The incidence observed in herd 1 (9.7 percent) is in agreement with the findings of other research workers who observed an incidence of 10 to 15 percent in problem herds. Only one sow in herd 2 was positive. A breed difference in herd 1 was observed with Yorkshire sows exhibiting a higher incidence of *B. bronchiseptica* than Hampshire sows. The highest incidence was observed in Yorkshire gilts in herd 1.

It should be noted that although the positive sows were swabbed numerous times (a miximum of seven times for one positive sow), no sow was positive more than once (Table 2). This lack of repeatability of positive swabs needs to be explained before this system has any practical applications as a means of eliminating carrier animals in this herd. It is posible that *B. bronchseptica* exisits in large numbers in the nasal passages of carrier animals in one herd and are present in

Table 1. **Incidence of Bordetella Bronchiseptica in Sows and Gilts From Two OSU Swine Herds**

Breed Groups	Herd 1[1] No. Swabbed[3]	Herd 1[1] No. positive	Herd 1[1] % positive	Herd 2[2] No. Swabbed[4]	Herd 2[2] No. positive	Herd 2[2] % positive
Duroc sows	--	--	--	27	0	0
Hampshire sows	35	1	2.8	32	1	3.1
Hampshire gilts	20	0	0	--	--	--
Yorkshire sows	41	5	12.2	30	0	0
Yorkshire gilts	28	6	21.4	--	--	--
Total	124	12	9.7	89	1	1.1

[1] OSU teaching herd.
[2] OSU animal breeding herd.
[3] A total of 299 swabs were made and each sow was swabbed from 2 to 7 times.
[4] All sows were swabbed twice.

Table 2. **Repeatability of Bordetella Swabs in Positive Sows**

Sow No.	No. of Swab 1	2	3	4	5	6	7
Y 91-1	—[1]	—	—	+[2]	—	—	—
Y 29-5	+	—	—	—	—		
H 15-2	—	—	+	—			
Y 15-11	—	—	+				
Y 60-6	+	—	—				
Y 17-4	+	—					
H 69-6	+	—					

[1] Indicates negative to *Bordetella bronchiseptica.*
[2] Indicates positive to *Bordetella bronchiseptica.*

only a small number of colonies in the nasal passages of carrier animals in another herd. If this is the case, the nasal passage swab and culture approach could be effective in eliminating carrier animals in one herd and not effective in another.

Phase II

The second phase of this study was initiated to determine if differences exist in the bacterial populations in sows and litters with early symptoms of atrophic rhinitis compared to sows and litters not showing early symptoms of the disease. The relationship between early symtoms of atrophic rhinitis and evidence of turbinate atrophy at slaughter was also studied.

A total of 5 sows with litters showing symptoms of atrophic rhinitis were selected as the "diseased" group and a group of 6 sows with litters not showing evidence of atrophic rhinitis were selected as the "control" group. Early symptoms used to designate a litter as a "diseased" litter included sneezing, nasal discharge, irritation of the nasal passages (such as rubbing of the snout against convenient objects), and discharge from the eye.

Sows and litters were divided into the two groups as quickly after farrowing as possible and moved from the farrowing house to two separate nursery facilities. This procedure permitted the isolation of the two groups until the pigs were slaughtered. The sows from each litter were swabbed at two week intervals until the litters were weaned. Four pigs from each litter were swabbed at two week intervals until the pigs reached 3 months of age. Another swab check was made when the pigs reached 4 and 5 months of age.

The pigs involved in the swabbing checks were slaughtered and the maximum distance from the scroll of the turbinates to the parietal surface of the nasal cavity was measured. An antibiotic sensitivity check was made on all isolates of *B. bronchiseptica*.

The incidence of selected bacteria from the "control" and "diseased" groups is presented in Tables 3 and 4. The incidence of *B. bronchiseptica* throughout the trial in both groups was very low. Only one positive culture from a total of 129 samples was observed in the "control" group and none of the sows were positive. Only one sow in the "diseased" group was positive to *B. bronchiseptica*, but 20 percent of the pigs at approximately four months of age were positive. Other workers have observed a very high incidence of *B. bronchiseptica* in young pigs with a gradual decline in the incidence with age. No differences between the "diseased" and "control" groups in the incidence of other bacteria were observed except for the increased incidence of *Pasteurella multocida* in the "diseased" sows. *Pasteurella multocida* has been implicated as a causative agent for rhinitis. The incidence of mycoplasma ranged from 20 to 47 percent and did not appear to differ greatly between treatment groups.

The average maximum distance from the scroll of the turbinates to the parietal surface of the nasal cavity was greater for the "diseased" pigs than for the "control" pigs (Table 5). This suggests that more turbinate atrophy had occurred in the "diseased" group. Of the pigs slaughtered only one of 13 pigs in the "diseased" group could be listed as negative to atrophic rhinitis while 10 of 18 could be listed as negative to

Table 3. Incidence of Selected Bacteria from "Control" Sows and Litters

	Sow		Pigs					
	Farrow to weaning		Month 1, 2, 3		Month 4		Month 5	
Microorganism	Total No. of swabs	% Positive	Total No of swabs	% Positive	Total No. of swabs	% Positive	Total No. of swabs	% Positive
Bordetella bronchiseptica	13	0	89	1.1	15	0	11	0
Pasteurella haemolytica	13	61.5	99	86.9	15	80	11	27
Pasteurella multocida	13	0	99	4.0	15	0	11	0
Pasteurella species	13	7.7	99	13.1	15	27	11	0
Mycoplasma	12	25.0	86	33.0	15	0	4	0

Table 4. Incidence of Selected Bacteria from "Diseased" Sows and Litters

	Sow		Pigs					
	Farrow to weaning		Month 1, 2, 3		Month 4		Month 5	
Microorganism	Total No. of swabs	% Positive	Total No of swabs	% Positive	Total No. of swabs	% Positive	Total No. of swabs	% Positive
Bordetella bronchiseptica	15	6.7	116	0	20	20.0	13	0
Pasteurella haemolytica	15	86.7	112	76.8	20	85.0	13	69.2
Pasteurella multocida	15	20.0	112	3.6	20	0	13	0
Pasteurella species	15	20.0	116	11.2	20	15.0	13	15.0
Mycoplasma	15	20.0	103	47.6	20	0	11	0

Table 5. Turbinate Atrophy of Pigs at Slaughter

	No. Pigs	Average Turbinate Measurement, mm[1]	Percent Positive[2]	Percent Negative[3]	Percent Suspect[4]
"Control" pigs	18	5.1	33	56	11
"Diseased" pigs	13	7.9	77	8	15

[1] Maximum distance from the scroll of the turbinates to the parietal surface of the nasal cavity.
[2] Pigs with maximum distance of 8 mm or more for right or left nasal passage.
[3] Pigs with maximum distance of 5 mm or less for right or left nasal passage.
[4] Pigs with maximum distance from 5 to 8 mm for right or left nasal passage.

Table 6. Sensitivity Test of all Bordetella Bronchiseptica Cultures Isolated

Antibiotic	No. Samples	No. Resistant	% Resistant
Chloromycetin	19	17	89
Erythromycin	19	18	95
Furadantin	19	19	100
Gentomycin Sulfate	19	2	10
Neomycin	19	19	100
Penicillin	19	19	100
Streptomycin	19	19	100
Sulfamerizine	19	19	100
Sulfamethazine	19	19	100
Sulfathiazole	19	19	100
Tetracycline	19	4	21

atrophic rhinitis in the "control" group. Two pigs from each group were listed in the suspect category.

The results of the sensitivity test for all nineteen of the samples of *B. bronchiseptica* are presented in Table 6. *Bordetella bronchiseptica* isolates were sensitive to only tetracycline and gentomycin sulfate. It is interesting to note that all isolates were resistant to all three sulfonamides. This is in agreement with the recent findings of an 80 percent resistance of *B. bronchiseptica* to sulfonamides in Iowa.

A Preliminary Evaluation of Reproductive Performance and Further Evaluation of Growth and Carcass Characteristics of 1/4 Finish Landrace Lambs

L. D. Flinn, M. B. Gould, J. V. Whiteman and J. E. Fields

Story in Brief

A great deal of thought and effort has been expended to find a ewe that under Oklahoma conditions will produce and rear as many good growthy lambs as possible in her lifetime. In a further attempt to find this ewe the first replicate of some experimental ewe lambs were born at Fort Reno in the spring of 1971, and a second replicate was born in the spring of 1972.

There are five different breed combinations that will be evaluated over a 7 year period to compare them for suitability as commercial ewes under Oklahoma conditions. The breeding combinations consist of: (1) ½ Dorset X ½ Rambouillet (control ewes), (2) ¼ Finnish Landrace—¼ Dorset X ½ Rambouillet, (3) ¼ Finnish Landrace—¼ Rambouillet X ½ Dorset, (4) ¼ Dorset X ¾ Rambouillet and (5) ¼ Finnish Landrace X ¾ Rambouillet (born in 1972 only).

In both years the ¼ Finnish Landrace—¼ Rambouillet X ½ Dorset lambs averaged about one pound lighter at birth than the other groups. All groups were similar in rates of gain to weaning at 70 days of age and in 70-day weights. The ¼ Dorset X ¾ Rambouillet lambs outgained all other groups on post weaning rate of gain (.53 lbs./day vs. approximately .48 lbs./day for other breed combinations). The ¼ Dorset X ¾ Rambouillet also had a greater average daily gain from birth to market (.55 lbs./day) than the other groups of lambs (approximately .51 lbs./day).

In cooperation with USDA Agricultural Research Service, Southern Region.

From two to six wethers from each of the five breed combinations were slaughtered at the Oklahoma State University meat lab. Generally there were no differences due to Finnsheep breeding in the loin eye area, backfat thicknesses or quality grades. In both years the Finnsheep groups had dressing percentages about 3 percent lower than the Dorset X Rambouillet groups.

The ewe lambs born in 1971 were mated at 7 months of age to lamb at 12 months of age. The ewes of ¼ Finnish Landrace breeding averaged 25 percent more ewes conceiving with slightly more lambs born per ewe lambing (1.28 and 1.10 lambs/ewe vs. 1.05 and 1.00 lambs/ewe for the Dorset X Rambouillet groups).

Introduction

One of the main areas of sheep production that can be vastly improved is lamb production per ewe. This can be accomplished by increasing the number of lambs born per ewe lambing (lamb crop percent) or by shortening the interval between lambings for each ewe (lamb more than once a year). Research at Fort Reno over the past years has shown that the ½ Dorset X ½ Rambouillet ewe was superior in reproductive rate to the straightbred Dorset or straightbred Rambouillet on the basis of spring breeding and in twice-yearly lambing programs. The Rambouillet breed has been used because it is an out-of-season breeding sheep, and one of the most widely available western ewes. The Dorset was used because it also is an out-of-season breeding sheep and is prolific.

A source of new germ plasm is now available for use, the Finnish Landrace. The Finnish Landrace breed (Finn-sheep) is a medium size sheep somewhat deficient in wool production (a coarse wool) and muscling, but is well known for its outstanding prolificacy (often 4-5 lambs in a litter).

The Finnsheep originate in a cold climate very different from Oklahoma conditions and at present purebred Finnish Landrace rams are not available for widespread use. Rams of ½ Finnish Landrace breeding are much more available. Therefore, in 1970 a long range program was initiated at the Fort Reno Livestock Station to determine if a ewe of ¼ Finnish Landrace germ plasm could adapt to Oklahoma conditions and improve reproductive rates over the present recommended ewe breed cross. Since the ½ Dorset X ½ Rambouillet ewe turned out to be such a good ewe for Oklahoma commercial operations the ¼ Dorset X ¾ Rambouillet will also be tested in this project.

These results summarize comparisons of breed groups for birth weights, lamb growth performance (castrate males only), lamb mortality, a few major carcass characteristics and the first season's reproductive performance of the first replicate of ewe lambs. The program is not far enough along to get data from the offspring of the test ewes, therefore data collected and discussed are on the ewes themselves and their male sibs.

Materials and Methods

During 1970 and 1971 planned matings were made to produce test ewes of the desired breed crosses. The test ewes were born in two replicates, the first replicate in the spring of 1971 and the second replicate in the spring of 1972. The breed crosses to be tested are ½ Dorset X ½ Rambouillet (control group), ¼ Dorset X ¾ Rambouillet, ¼ Finnish Landrace–¼ Dorset X ½ Rambouillet, ¼ Finnish Landrace–¼ Rambouillet X ½ Dorset and ¼ Finnish Landrace X ¾ Rambouillet. The number of test ewes produced per year are shown in Table 1 along with the crosses used to produce the test ewes.

Management practices were the normal practices maintained at Fort Reno and were the same for all breeds of lambs. Lambs were born in the lot and then placed in lambing pens with their mother for 3 to 4 days. At this time lamb data was collected. All lambs had access to creep feed. The creep feed consisted of five percent molasses, 55 percent cracked milo, ten percent soybean meal and 30 percent ground alfalfa hay.

Table 1. The Breed Crosses Used to Produce the Test Ewes and the Number Kept for Testing Each Year[1]

Group	Breeding of Test Ewes	Test Ewe Sire Breed	Test Ewe Dam Breed	Number Born 1971	Number Born 1972
1	½ Dorset X ½ Ramb. (Control)	Dorset	Rambouillet	26	24
2	¼ Dorset X ¾ Ramb.	Rambouillet	½ Dorset X ½ Ramb.	28	24
3	¼ Finn X ¾ Ramb.	½ Finn X ½ Ramb.	Rambouillet	0	41
4	¼ Finn-¼ Dorset X ½ Ramb.[2]	a. ½ Finn X ½ Dorset b. ½ Finn X ½ Ramb.	Rambouillet ½ Dorset X ½ Ramb.	22	29
5	¼ Finn-¼ Ramb. X ½ Dorset[2]	a. ½ Finn X ½ Ramb. b. ½ Finn X ½ Dorset	Dorset ½ Dorset X ½ Ramb.	23	23

[1] The ¼ Finnish Landrace X ¾ Rambouillet ewe lambs were born in 1972 only.
[2] These breed crosses were produced by two different matings (a and b).

Starting when the oldest lambs reached 30 pounds, the lambs were all weighed biweekly. The lambs were weaned at approximately ten weeks of age and placed in a drylot feed area at the Fort Reno station. When the youngest lambs reached twelve weeks of age the soybean meal was removed from the creep ration and replaced with ground alfalfa hay. Due to the problem of internal parasites in springborn lambs, the lambs were never allowed out of the drylot area until final removal.

Ewe lambs that were saved as test ewes were removed from the drylot when they weighed 75 pounds on the biweekly weighings and placed on clean pasture. Therefore, the ewe lambs were not used in calculating post weaning rates of gain and overall average daily gains. They were bred at 7 months of age to compare their rates of sexual maturity since this is the first reproductive trait that these ewes will be compared for in the lang range project. The wethers were fed until they weighed 95 pounds or more and shipped to market. Some of the wether lambs were used for the carcass data given in this study.

In 1971, 43 wether lambs were sold for nutrition work at weaning time and, therefore, were only used in calculating birth weights, preweaning rate of gain and 70-day weights.

Results and Discussion

Death Losses

Death losses have been divided into two different categories; early death losses (before two weeks of age) and lambs that died between two weeks of age and market. Any deaths that occurred after 2 weeks of age were attributed mostly to chance and not breeding, therefore, only early death losses were reported here (Table 2). The ewes used to produce these lambs were young (4 and 5 years old) Rambouillet ewes and old Rambouillet, Dorset and ½ Dorset X ½ Rambouillet ewes (8-10 year old). Some lamb losses occurred because some old ewes did not give enough milk.

In 1971 the lambs of ¼ Finn breeding averaged about 6 percent higher death losses than lambs of the two Dorset X Rambouillet breed groups. The 1972 lambs of ¼ Finn–¼ Rambouillet X ½ Dorset breeding had very high early death losses of 26.6 percent while the ¼ Dorset X ¾ Rambouillet, ½ Dorset X ½ Rambouillet and ¼ Finn–¼ Dorset X ½ Rambouillet all had very similar early death losses of 13-17 percent. The ¼ Finn X ¾ Rambouillet lambs had the lowest death loss percentage (8.4).

When using older ewes there normally is a fairly high incidence of twins but quite regularly the ewe will not produce much milk, which

Table 2. The Number of Lambs Born and Early Death Losses[1] for the Breed Groups During the Two Years Test Ewes Were Being Produced

Breed Components	1971		1972	
	No. of Lambs Born	Early Death Losses (%)[1]	No. of Lambs Born	Early Death Losses (%)[1]
½ Dorset X ½ Ramb.	77	11.7	51	13.7
¼ Dorset X ¾ Ramb.	51	5.9	46	17.4
¼ Finn—¼ Dorset X ½ Ramb.	74	16.2	98	13.3
¼ Finn—¼ Ramb. X ½ Dorset	67	14.9	64	26.6
¼ Finn X ¾ Ramb.	0	0	119	8.4

[1] Death before 2 weeks of age including stillborn lambs.

results in high death losses among the young lambs. The ¼ Finn—¼ Rambouillet X ½ Dorset lambs were all produced from old ewes (as were the ¼ Dorset X ¾ Rambouillet ewes) and this may be a big factor in the very high 26.6 percent death loss of those lambs. The ¼ Finn X ¾ Rambouillet lambs were mostly offspring from the young Rambouillet ewes that generally did not have any problem producing milk. These ewes also produced fewer sets of twins than the older ewes. These two factors are most likely the reasons for the low (8.4%) death losses among the ¼ Finn X ¾ Rambouillet lambs.

The overall differences across both years are not significant; however, there does seem to be a trend for the Finnsheep to have slightly higher early death losses.

Lamb Growth Performance

The lambs from each group were evaluated over two years on the growth performance by comparing them for birth weight, rate of gain from birth to weaning, 70-day weight, post weaning rate of gain and average daily gain from birth to market (Table 3).

The ¼ Finn lambs in 1971 were lighter at birth (8.0 pounds and 8.8 pounds) than the Dorset X Rambouillet groups (9.2 and 9.6 pounds). In 1972, the ¼ Finn—¼ Rambouillet X ½ Dorset were again lighter than the other groups (8.8 pounds) with the two Dorset X Rambouillet groups being fairly equal again (9.4 and 9.3 pounds). However, the ¼ Finn—¼ Dorset X ½ Rambouillet lambs were heavier at 9.7 pounds and the ¼ Finn X ¾ Rambouillet lambs averaged 10.0 pounds at birth. The ¼ Finn X ¾ Rambouillet lambs were produced mostly from the

Table 3. Birth Weights and Mean Growth Performance of the Springborn Lambs

Measurement	1971				1972				
	1/2 D-1/2 R	1/4 D-3/4 R	1/4 F-1/4 D-1/2 R	1/4 F-1/4 R-1/2 D	1/2 D-1/2 R	1/4 D-3/4 R	1/4 F-1/4 D-1/2 R	1/4 F-1/4 R-1/2 D	1/4 F-3/4 R
Birth Weight	9.2	9.6	8.8	8.0	9.4	9.3	9.7	8.8	10.0
Rate of gain to 70 days	.60	.59	.61	.59	.58	.56	.52	.54	.57
70-day weights	51.2	50.9	51.5	49.3	50.0	48.5	48.5	46.6	49.6
Rate of gain from 70 days to mkt. (lbs/day)[1,2]	.51	.58	.52	.49	.41	.44	.43	.40	.41
Av. daily gain from birth to mkt. (lbs/day)[1,2]	.56	.59	.57	.54	.49	.50	.47	.47	.49
No. of lambs used to calculate avg. daily gain[1,2]	54	29	55	50	22	14	38	21	54

[1] Ewe lambs were not used for post weaning rate of gain or average daily gain.
[2] 43 wethers were sold at weaning time in 1971.

young Rambouillet ewes. They are very large ewes.

Across the two years (1972 only for the ¼ Finn X ¾ Rambouillet) the ¼ Finn—¼ Rambouillet X ½ Dorset lambs averaged significantly lighter birth weights than the three other breeds with the ¼ Finn X ¾ Rambouillet heaviest of all. The increased Rambouillet breeding seems to increase birth weights slightly. This is partly due to the fact that most of the Rambouillet ewes used to produce test ewes were young ewes (4-5 years old) while the ½ Dorset X ½ Rambouillet and Dorset ewes were all old ewes (8-10 years old).

Within each of the two years and averaging across both years all five groups compared favorably on pre-70 day rate of gain and 70-day weights. The ¼ Dorset X ¾ Rambouillet lambs in 1971 had the fastest rate of gain from 70 days to market (.58 lbs./day) with all other groups being similar (.51 lbs./day). In 1972 all five groups gained very similarly and quite slowly (.40 lbs./day to .44 lbs./day). The ranking of breeds for fastest to slowest post-weaning rates of gain did not change from 1971 to 1972 even though they were very similar in 1972 (Table 3). The slow post-weaning rates of gain and average daily gains in 1972 were due to a hot summer and poor alfalfa for the creep ration.

Reproductive Performance

The ewe lambs that were born in the spring of 1971 (four of the five breed combinations) were mated during the fall at about seven months of age to produce lambs at 12 months of age. Their reproductive performance is shown in Table 4.

Only one of the 45 ewes with Finnsheep breeding did not mate at all while 7 out of the 54 Dorset X Rambouillet ewes did not mate at 7 months of age (4 out of the 7 were control ewes). The ewe lambs of ¼ Finn breeding averaged 25 percent more ewes conceiving at seven months of age to lamb as yearlings than the Dorset X Rambouillet crosses (81.8% and 91.3%) of those available to be mated and conceive

Table 4. Lambing and Mating Performance of the First Replicate of Ewes

Ewe Breeding	No. Avail.	Ewes Not Mated	Ewes that Lambed No.	Ewes that Lambed %	Lambing Rate No.	Lambing Rate %	Avg. Conc. Age
½ Dorset X ½ Ramb. (control)	26	4	19	73	20	105	229.3
¼ Dorset X ¾ Ramb.	28	3	14	50	14	100	226.4
¼ Finn—¼ Dorset X ½ Ramb.	22	1	18	82	23	128	216.4
¼ Finn—¼ Ramb. X ½ Dorset	23	0	21	91	23	110	224.7

vs. 73.1% and 50.0%). Only 50% of the ¼ Dorset X ¾ Rambouillet ewe lambs that were exposed to rams actually lambed.

Of those ewes that did lamb the ¼ Finn—¼ Dorset X ½ Rambouillet ewes averaged more lambs per ewe lambing than the other three breed groups (1.28 lambs per ewe vs. 1.10, 1.05 and 1.00 lambs per ewe). The ¼ Finn—¼ Dorset X ½ Rambouillet ewes also conceived about 10 days sooner (216 days of age) than the other three breed groups, all of which were approximately equal (226 days of age). These data show that the ¼ Finn breeding may help the producer to get more lambs from young ewes if he mates them at seven months of age. More data will be available next year to add to our information on this subject.

Carcass Characteristics

In 1971, 24 wethers of three of the breeds were slaughtered to test carcass merit. Twenty-one more lambs (at least two of each breed cross) were slaughtered in 1972 and the carcass characteristics were measured. All lambs for both years were cut and evaluated for carcass weights, loin eye area, backfat thickness, quality grade, leg conformation grade, cutability and dressing percent. (Table 5). During both years the lambs to be slaughtered were held over too long after they should have been sent to slaughter and were too fat.

There were no great differences in either year or over both years in the loin eye area or cutability. In 1971 the Finnsheep groups had lower quality grades and leg conformation grades than the ½ Dorset X ½ Rambouillet lambs, however, in 1972 the three Finnsheep groups had quality grades higher than the Dorset X Rambouillet groups and were equal on leg conformation grades (except the ¼ Finn X ¾ Rambouillet were one grade point lower).

Rankings on backfat thickness changed drastically from one year to the next, but there is a trend for lambs of increasing Rambouillet breeding to have less backfat on their carcasses.

The two Finnsheep groups in 1971 had lower dressing percentage (about 3%) than the ½ Dorset X ½ Rambouillet and in 1972 the ranking was the same but the ¼ Finn—¼ Rambouillet X ½ Dorset lambs were about equal to the ½ Dorset X ½ Rambouillet (57.0% vs. 58.3%). Dressing percentages were quite high in 1972 partly because of fat carcasses when they were held too long before slaughter.

Table 5. Mean Comparisons for Slaughter Measurements

Measurement	Mean							
	1971			1972				
	1/2 D-1/2 R	1/4 F-1/4 D-1/2 R	1/4 F-1/4 R-1/2 D	1/2 D-1/2 R	1/4 F-1/4 D-1/2 D	1/4 F-1/4 R 1/2 D	1/4 D-3/4 R	1/4 F-3/4 R
No. of lambs	8	8	8	3	5	5	6	2
Live wt. at Fort Reno (lbs)[1]	98.8	96.4	98.4	84.0	96.6	95.8	95.3	98.0
Chilled carcass weight (lbs)	49.7	46.0	47.9	49.0	51.9	54.6	50.7	55.8
Dressing percent	50.3	47.9	48.8	58.3	53.7	57.0	53.2	56.3
Cutability	42.8	43.0	43.5	43.5	43.2	43.0	43.9	44.3
Carcass quality grade[2]	12.6	11.5	12.1	11.3	11.6	12.6	11.7	11.0
Leg conformation grade	13.3	11.4	12.8	10.7	10.8	10.8	9.8	10.5
Loin eye area	2.08	1.90	2.06	1.96	1.96	2.07	1.90	2.12
Backfat thickness	.32	.27	.29	.30	.31	.32	.24	.26

[1] Sheared weight.
[2] Grade code is on a scale of 1 to 15, 11 being average choice, 12 high choice and 13 low prime.

The Interaction of Level of Concentrate And Supplementary Nitrogen Source on Performance of Growing-Finishing Lambs

R. Wyatt, R. R. Johnson and E. T. Clemens

Story in Brief

To study the performance of growing-finishing lambs fed various levels of concentrate supplemented with different nitrogen sources eighty young lambs were allotted to 16 different ration combinations and fed for 98 days. The rations consisted of cottonseed hulls as the roughage source and contained 20, 40, 60 and 80 percent ground corn. All levels of corn were fed with either soybean meal, urea or biuret as supplementary nitrogen sources.

Average daily gains for the lambs were increased to a maximum at 0 percent corn and no further improvement was demonstrated at 80 ercent corn. Soybean meal proved to be a superior source of supplemen- ry nitrogen at the 20 and 40 percent concentrate levels but there were significant differences due to nitrogen sources at the 60 and 80 per- nt concentrate levels. Much of the poor performance of animals fed e 20 and 40 percent concentrate levels supplemented with urea and uret was due to decreased feed consumption.

Introduction

Continued efforts are being made to evaluate non-protein nitrogen rces as supplements to rations for ruminant animals. Although natural tein sources such as soybean meal (SBM) have generally been superior non-protein nitrogen sources, they are considerably more expensive unit of nitrogen. On the other hand, the non-protein nitrogen sources ess certain disadvantages which prevent their exploitation in all s. Urea, for example, has not been found to be as useful in high hage rations as it has in high concentrate rations. Biuret, another N source which is presently under intensive investigation, has been osed as being more useful for high roughage rations than urea be- of its slower breakdown in the rumen.

Few reports exist, however, where both of these non-protein nitrogen es have been compared to soybean meal as the supplementary gen source at different concentrate levels. The objectives of the reported here were to compare these three nitrogen sources as supplements to rations containing variable levels of concentrate when fed to growing-finishing lambs.

Materials and Methods

Eighty fall born wether lambs weighing approximately 53 pounds were alloted by weight to 16 groups represented by the rations illustrated in Table 1. The lambs were randomly assigned by location to the pens in the lamb feeding area and were housed and fed individually throughout the entire feeding period. All lambs were allowed to consume their rations *ad libitum* and were allowed water free choice. Lamb weights were taken at 2 week intervals for a 98 day feeding period.

The rations consisted basically of cottonseed hulls as the roughage source and were formulated with either 20, 40, 60 or 80 percent corn. Rations 1-4 were designed to be low but equal protein rations. The 80 percent corn ration had over 5 percent digestible protein as a result of the corn contribution; thus SBM was added to rations 1, 2 and 3 to provide 5 percent digestible protein. As a result, these rations were not greatly lower in protein than rations 5-8. SBM, urea, and biuret provided the major portion of the supplementary nitrogen in rations 5-8, 9-12 and 13-16, respectively.

At two different times during the feeding period four lambs each on rations 5, 6, 7, 8, 13, 14, 15 and 16 were equipped with feces collection harnesses. Total feces collections were made for a 7 day period in each case for purposes of calculating digestibility. Routine methods were utilized for compositing the feces, drying, grinding and analyzing in the laboratory as well as for analyzing the feed.

Results and Discussion

The average daily gains, average daily feed consumptions and feed required per unit of gain values are reported in Table 2. Over all nitrogen sources the performance of the lambs improved as the level of concentrate was increased from 20 to 60 percent. However, there were no differences between the performance at 60 or 80 percent concentrate. At the 20 and 40 percent corn levels soybean meal as a supplementary nitrogen source supported much better gains than either urea or biuret.

Although there were some differences due to nitrogen source at the 60 and 80 percent corn levels, these differences were not statistically significant. In reviewing the formulation of the ration, however, it should be kept in mind that at the higher concentrate levels the supplementary nitrogen sources contributed only a very small portion of the total digestible protein because most of the requirement was supplied by the

Table 1. Composition of Rations — Level of Concentrate and N-Source Trial

Ingredient	Percentage, air dry basis															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Ground corn	20.00	40.00	60.00	80.00	20.00	40.00	60.00	80.00	20.00	40.00	60.00	80.00	20.00	40.00	60.00	80.00
Cottonseed hulls	64.90	48.00	31.20	13.00	62.80	45.30	28.50	11.70	70.20	51.00	31.90	12.70	71.00	51.60	32.20	12.80
Soybean meal	8.14	4.96	1.78	....	10.80	7.65	4.47	1.29	1.38	0.98	0.57	0.17	....	....	....	....
Urea	....	....	....	....	....	....	....	....	1.38	0.98	0.57	0.17	....	....	....	....
Biuret[1]	....	....	....	....	....	....	....	....	....	....	....	....	1.93	1.36	0.80	0.23
Dried molasses	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Limestone	0.27	0.35	0.45	0.52	0.25	0.34	0.42	0.51	0.14	0.38	0.45	0.52	0.11	0.37	0.45	0.53
Dicalcium phosphate	0.02	....	....	....	....	....	....	....	0.26	0.02	....	....	0.3	0.05	....	....
T.M. salt	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Vitamins A & D	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

[1] "Pure" biuret containing 36% N of which over 95% came from biuret.

Acid Hydrolyzed Wood Residue as an Ingredient in Ruminant Rations

R. R. Johnson, J. W. Butterbaugh and M. McGeehon

Story in Brief

The nutritive value of acid processed wood residues for ruminants was studied in 5 growth, performance and digestion trials with sheep and beef cattle.

Two materials were tested, LA-HWR which was processed at 0.8 percent H_2SO_4 and HA-HWR which was processed at 2.3 percent H_2SO_4. LA-HWR was highly palatable and had a dry matter digestibility of approximately 32 percent. This is sufficient to be encouraging as a potential source of energy for ruminants on maintenance levels of subsistence such as beef cows. HA-HWR was unpalatable and appeared to be considerably less digestible. Thus, the acid processing can be carried too far. Intermediate levels were not tested.

Introduction

Because of recent emphasis on the impact of pollutants on the environment, numerous efforts are underway to attempt to find economic uses for items one time discarded. If the pollutants are biodegradable, one might provide the best solution by developing means for accelerating this degradation. If the degradation can contribute to some economic enterprise as well, then society is benefited in two ways. Wood residues from lumber mills, pulping plants and paper factories represent an immense quantity of material for which disposal means are either lacking or prohibited.

The ruminant animal possesses a biodegradation capability in its rumen enabling it to economically utilize plant feedstuffs which are indigestible by other types of animals. Wood residues consist of complex cell wall carbohydrates similar to other plant feedstuffs but which are essentially undigestible in the ruminant because of the physical complexing with a material called lignin which prevents microbial attack on the carbohydrates. Attempts to solve this problem have involved chemical treatment to (1) remove the lignin or (2) hydrolyze the carbohydrate away from the lignin and produce a product in which the carbohydrate is digestible.

Although the former process is now known to be quite feasible, the economics of treating large quantities of material by this means are with a mineral acid, appears to be more feasible economically but has not been studied as well. The objective of this study was to determine the nutritive value of acid hydrolyzed hardwood residues for ruminants.

Materials and Methods

The two products tested were produced by the Dierks Division, Weyerhaeuser Corp., Hot Springs, Ark. Mixtures of 4 parts hardwood to 1 part pine were coarsely ground. Low acid hydrolyzed wood residue (LA-HWR) was produced by treating the wood with 0.8 percent H_2SO_4 for 60 seconds at 600 p.s.i. High acid hydrolyzed wood residue (HA-HWR) was produced with 2.3 percent H_2SO_4 at the same pressure for 40 seconds. Both products were neutralized with anhydrous ammonia and allowed to "cook" in a closed room for 24 hours prior to being cooled to ambient temperatures. The products varied from 50 to 60 percent dry matter.

Trial 1

Thirty-four wether lambs were allotted to the 6 rations shown in Table 1. The basal ration was alfalfa meal and LA-HWR was substituted for 25, 50 and 75 percent of the alfalfa meal. In rations 2, 3 and 4; soybean meal (SBM) was added to make the rations have equal crude protein content. Rations 5 and 6 contained 50 and 75 percent LA-HWR without added SBM. All lambs were housed in individual pens and provided both feed and water free choice for 89 days.

Daily feed consumption was recorded and all animals were weighed at 2 week intervals. Feces were collected from all lambs for two 7 day periods during the trial to determine ration digestibilities. The feed and feces were analyzed chemically by routine procedures.

Trial 2

Thirty growing wether lambs were allotted to the rations shown in Table 3. In this trial HA-HWR was again substituted for alfalfa meal but due to the low palatability of this product, 35 percent was the highest level of substitution possible. Feces collections were again made at 2 times during the 90 day feeding period. Procedures for the growth trial and the digestion trials were the same used in trial 1.

Trial 3

This trial was conducted to determine the ability of hydrolyzed wood residue to support the growth and maintenance of beef steers. The rations as shown in Table 5 were designed to support a rate of gain typical of

Table 1. Composition of LA-HWR Rations and Performances of Lambs fed These Rations (Trial 1)

Item or measurement	1 Basal	2 25% LA + SBM	3 50% LA + SBM	4 75% LA + SBM	5 50% LA	6 75% LA
			% Composition, dry basis			
Alfalfa meal	99.5	70.6	40.5	11.1	48.7	23.0
LA-HWR	—	25.0	50.0	75.0	50.0	75.0
Soybean meal	—	3.9	8.2	12.4	—	—
T.M. salt	0.5	0.5	0.5	0.5	0.5	0.5
Dicalcium phosphate	—	—	0.8	1.0	0.8	0.5
Vitamin D supp.	+	+	+	+	+	+
			Growth and Feed efficiency			
No. lambs	5	6	6	6	5	6
Ave. daily gain, lb.	.44[12]	.51[1]	.42[23]	.37[3]	.40[23]	.26[4]
Ave. daily DM consumption, lb.	3.12	3.98	3.78	3.87	3.61	3.19
DM intake per lb. gain, lb.	6.99[1]	7.90[1]	9.31[2]	10.37[2]	9.43[2]	12.60[3]
Non-wood DM intake per lb. gain, lb.	6.99[1]	5.93[1]	4.66[2]	2.59[3]	4.72[2]	3.15[3]

[1234] Means with unlike superscript are significantly different ($P < .05$).

Table 2. Coefficients of Digestibility for LA-HWR Rations (Trial 1)

Item	Apparent Digestibilities, % Basal	25% LA + SBM	50% LA + SBM	75% LA + SBM	50% LA	75% LA
Dry matter	57.6[1]	51.2[2]	45.1[3]	38.8[4]	38.8[4]	36.8[4]
Organic matter	57.8[1]	50.8[2]	45.1[3]	38.4[4]	38.3[4]	36.4[4]
Cellulose	37.6	38.6	35.6	39.8	34.0	39.9
Nitrogen	61.2	59.3	59.3	58.4	51.3	45.4

[1234] Means with unlike superscript are significantly different ($P < .05$).

"wintering" rations. HA-HWR was substituted at the 20, 30 and 40 percent level. Twenty four steers were allotted by weight to the 4 rations groups and were self-fed the rations for 65 days. Two steers were removed from lot 2 for health reasons not associated with the rations. Eighteen hour shrunk weights were recorded every two weeks.

Table 3. Composition of HA-HWR Rations and Performance of Lambs fed These Rations (Trial 2)

Item or measurement	Basal	20% HA + SBM	35% HA + SBM	20% HA	35% HA
% Composition, dry basis					
Alfalfa meal	99.5	73.3	52.8	79.5	64.0
HA-HWR	—	20.0	35.0	20.0	35.0
Soybean meal	—	6.2	11.5	—	—
T.M. salt	0.5	0.5	0.5	0.5	0.5
Dicalcium phosphate	—	—	0.2	—	0.5
Vit. D supp.	+	+	+	+	+
Growth and Feed efficiency					
No. lambs	6	6	6	6	6
Ave. daily gain, lb	.37^{1}	.31^{2}	.29^{2}	.29^{2}	.24^{2}
Ave. daily dry matter consumption, lb	2.95	2.95	3.08	2.99	3.04
DM intake per lb gain, lb	7.97^{1}	10.21^{2}	11.50^{23}	11.04^{23}	12.16^{3}
Non-wood dry matter per lb gain, lb	7.97	8.17	7.50	8.82	7.99

^{123} Means with unlike superscript are significantly different ($P < .05$).

Table 4. Coefficients of Digestibility for HA-HWR Rations (Trial 2)

	Apparent Digestibility, %				
Item	Basal	20% HA + SBM	35% HA + SBM	20% HA	35% HA
Dry matter	54.8^{1}	50.5^{12}	45.7^{34}	48.8^{23}	43.2^{4}
Organic matter	54.2^{1}	50.1^{12}	45.1^{34}	48.4^{23}	43.0^{4}
Cellulose	42.4^{1}	39.7^{1}	29.6^{2}	39.2^{1}	42.2^{1}
Nitrogen	56.6^{1}	55.2^{1}	51.9^{12}	49.5^{23}	46.0^{3}

^{1234} Means with unlike superscript are significantly different ($P < .05$).

Table 5. Composition of HA-HWR Steer Rations and Performance of Steers fed the Rations (Trial 3)

Item	1 Basal	2 20% HA	3 30% HA	4 40% HA
	% Composition, as is basis			
Alfalfa meal	99.5	68.4	55.6	44.6
HA-HWR	—	38.1	43.6	54.6
T.M. salt	0.5	0.5	0.4	0.4
Dicalcium phosphate	—	—	0.4	0.4
% Dry matter in feed	89.3	77.8	72.7	67.4
	Growth and performance			
No. steers	6	4	6	6
Ave. daily gain, lb	1.79	1.54	0.88	0.82
Ave. daily feed, lb. D.M.	15.6	16.6	12.8	12.7
Feed D.M. per lb gain, lb	8.7	10.8	14.5	15.5

Trial 4

The ability of HA-HWR to support the maintenance requirement of adult sheep was studied with 12 aged wethers allotted to three rations shown in Table 6. In this case cottonseed hulls (CSH) were used as the main component in the basal ration and HA-HWR was substituted for this ingredient. Using standard textbook values, a theoretical value for total digestible nutrients and digestible protein was calculated for each ration. The TDN value of HA-HWR was assumed to be 40 percent based on the previous experience with LA-HWR (this trial was conducted before the results of trials 2 and 3 were available). All sheep were then individually fed daily the amount of ration calculated to meet their maintenance requirement. Portions were recalculated as the weight of various sheep changed. All sheep were weighed weekly.

Trial 5

Digestibilities of rations similar to those used in trial 4 were determined using 6 aged wethers allotted to the three rations shown in table 7 in a 3 x 3 latin square design. During each period of the trial, the rations were fed for an 11 day preliminary adjustment and feces were collected over a 10 day period. Procedures for analyzing feed and feces were routine.

Results and Discussion

As the level of LA-HWR was increased in the ration, the growth rate of lambs decreased (Table 1). When SBM was included, however, the gains by lambs fed 25 and 50 percent LA-HWR were not signifi-

Table 6. Composition of Rations and Weight Changes of Aged Sheep on HA-HWR Maintenance Study (Trial 4)

Ingredient	1 Basal	2 25% HWR	3 50% HWR
	% Composition, dry basis		
Cottonseed hulls	80	55	30
HA-HWR	—	25	50
Cottonseed meal	9	9	9
Alfalfa meal	10	10	10
Minerals	1	1	1
	Maintenance data		
No. sheep	4	4	4
Ave. weight, lb			
5-18-71	124	126	124
6-10-71	123	119	116
6-24-71	126	120	111
7-8-71	127	121	110

cantly different from those fed the basal ration. Gains were lower, however when lambs were fed 75 percent LA-HWR with SBM or 50 and 75 percent LA-HWR without SBM. Daily consumption of ration dry matter was not decreased by the presence of LA-HWR.

Dry matter required per unit of gain was increased at all levels above 25 percent LA-HWR. The non-wood dry matter intake per unit of gain was calculated to determine if the wood material was being used for maintenance and growth. As shown in Table 1, as the level of LA-HWR increased, the amount of non-wood dry matter required per unit of gain decreased significantly. This is positive proof that the LA-HWR was indeed being utilized as an energy source.

Table 2 shows the digestibility coefficients for the LA-HWR rations. Both dry matter and organic matter digestibilities decreased as the level of LA-HWR increased in the ration. By using regression techniques, the dry matter digestibility of the LA-HWR component of the ration was calculated to be 32 percent. Although this may seem low, it is far better than the digestibility of the original wood material and approaches the digestibility of some low quality roughages. This supports the conclusion from the growth trial that the material was being partially utilized. Nitrogen digestibility was decreased in those rations not containing SBM so the high level of N provided by the anhydrous ammonia was apparently partially bound in a non-absorbable form.

The growth and performance of lambs fed HA-HWR are shown in Table 3 and the digestibilities of these rations are reported in Table 4. In contrast to the previous trial, lamb gains were depressed at all levels of HA-HWR. Although daily feed consumption was not changed, the HA-HWR was obviously not being utilized for growth as indicated by the dry matter and non-wood dry matter requirements per unit of gain. Dry matter and organic matter digestibilities were sharply depressed by HA-HWR, considering the fact that the maximum level in the ration was 35 percent. Using regression techniques again, it was determined that the dry matter digestibility of HA-HWR was probably less than 10 percent. Cellulose and nitrogen digestibilities were apparently less than in LA-HWR also.

Trial 3 was designed to determine if HA-HWR could contribute to the energy requirements for maintenance and growth of beef steers. Their performance is shown in Table 5. As the level of HA-HWR increased up to 30 percent in the ration, the rate of gain decreased sharply, with gains at 40 percent about the same as at 30 percent. The 20 percent HA-HWR ration was actually consumed as well or better than the alfalfa meal ration but consumption of the 30 and 40 percent HA-HWR rations was depressed considerably. Feed required per unit of gain was higher for all HA-HWR rations.

When the weekly consumption of these rations was observed, it could be seen that consumption of the 30 and 40 percent HA-HWR rations was less than half of that for the first two rations during the first week. After that, consumption of the HA-HWR rations increased gradually but not sufficiently to support comparable gains. The animals in lots 3 and 4 all lost weight for the first 3 weeks before beginning to gain weight for the remainder of the trial.

In the maintenance study with CSH-HA-HWR rations (trial 4, Table 6), the weights of the sheep on the control ration did not change appreciably while those consuming 25 percent HA-HWR decreased only slightly in weight. Both these groups consumed all their allotted feed while those on 50 percent HA-HWR did not consume all their feed regularly, especially at the beginning of the trial. This third group lost weight at first but they seemed to stablize as consumption became more regular and the body weight to maintain decreased.

Digestibility of similar cottonseed hull—HA-HWR rations is shown in Table 7 (trial 5). Although digestibility of dry matter and organic matter decreased with increasing levels of HA-HWR, the decreases were not as severe as noted with alfalfa—HA-HWR mixtures in trial 3. In fact, N-digestibility actually increased with the addition of HA-HWR. The reasons for somewhat better performance when mixed with CSH as compared to alfalfa meal are not known.

Table 7. Composition and Digestibility of CSH-HA-HWR Rations (Trial 5)

Ingredient	1 Basal	2 25% HWR	3 50% HWR
	% Composition, dry basis		
Cottonseed hulls	75	50	25
HA-HWR	—	25	50
Cottonseed meal	14	14	14
Alfalfa meal	10	10	10
Minerals	1	1	1
	Apparent Digestibilities, %		
Dry matter	50	47	45
Organic Matter	50	47	44
Cellulose	49	53	51
Nitrogen	35	52	54

Conclusions

These results suggest that wood residues could be processed to produce a material having nutritive value for ruminants. The LA-HWR had a dry matter digestibility of 32 percent and was highly palatable. On the other hand, when the acid level during treatment was increased from 0.8 percent (LA) to 2.3 percent (HA), a product was produced which not only had a low apparent digestibility but was also quite unpalatable. Thus, the optimum treatment might have been somewhere in between these two acid strengths.

Other chemical analysis verified the fact that the changes produced by 2.3 percent acid were much more drastic than those produced at 0.8 percent. Although further work on this project is not presently underway, it would appear to be feasible to produce a product from woody material which could serve as a source of a part of the energy requirement of ruminants, especially those existing on maintenance level rations such as beef cows. Cursory examination of the economics of such an operation suggests the costs may be within reason but this has not been thoroughly researched.

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Adaptation to Biuret as an NPN Source and as influenced by the Level of Concentrate and Level of Biuret in the Ration in the Ration

E. T. Clemens, R. D. Wyatt and R. R. Johnson

Story in Brief

Utilization of biuret as an NPN source requires the development of the ability of rumen microorganisms to degrade biuret to ammonia. Although this adaptation time may involve several weeks on high roughage rations, the inclusion of a small amount of dietary concentrate has been shown to decrease the time required for maximum adaptation to 1-2 weeks.

Rations containing 20 percent ground corn supported the most rapid rate of adaptation when compared to higher levels of concentrate. When biuret provided less than 15 percent to 20 percent of the digestible protein, the biuretolytic activity of rumen contents was significantly reduced. Thus, there appears to be a minimum level of exposure to biuret as an NPN source to promote maximum utilization.

Introduction

A prime difficulty in the use of biuret as a supplemental protein source for roughage fed ruminants has been the lengthy adaptation period required by these animals before they are effectively able to utilize biuret. Experiments conducted at this university indicate that biuret must be fed for a period of two to five weeks before the rumen microorganisms can adequately degrade biuret to NH_3.

Additional studies, demonstrated that a small amount of concentrate enhanced the rate of adaptation. The following studies were undertaken to determine what effect the level of dietary concentrate has on the rate of adaptation and extent of biuret utilization by the rumen microorganisms. Also, the effect of the level of biuret in the ration on rate and extent of adaptation was studied.

Methods and Materials

Trial 1

Eight feeder lambs with permanent rumen cannulas were fed one of four experimental rations (Table 1). The levels of dietary concentrate were regulated by adding either 20, 40, 60 or 80 percent ground corn to

Table 1. Ration Composition for Sheep Fed Biuret and Various Levels of Concentrate. (Trials 1 and 2)

	% Composition, air dry basis					
	Trial 1				Trial 2[1]	
Ingredient (%)	1	2	3	4	2	3
Ground corn	20.0	40.0	60.0	80.0	21.2	22.3
Corn starch					18.8	37.7
Cottonseed hulls	74.9	55.4	36.0	16.6	55.4	36.0
Molasses	5.0	5.0	5.0	5.0	5.0	5.0
Biuret	2.13	1.55	0.98	0.40	2.13	2.13
Limestone	0.00	0.06	0.18	0.31	0.10	0.12
Dicalcium phosphate	0.60	0.53	0.46	0.37	0.52	0.61

[1] Trial 2 contained a ration identical to ration 1, trial 1.

the complete mixed rations. The level of biuret was adjusted such that all rations were equal in digestible protein content.

Rumen contents were collected from each animal on days 0, 2, 4, 7, 10 and 14 for laboratory analysis. The ability of the rumen microorganisms to degrade biuret to ammonia (biuretolytic activity) was determined by incubating the rumen contents with a biuret solution at 39° C and measuring the disappearance of biuret over a 24 hour period.

Trial 2

Three rations containing either 20, 40 or 60 percent concentrate (Table 1) were fed to nine rumen cannulated sheep. However, in this trial the level of dietary concentrate was regulated by adding corn starch over and above the 20 percent ground corn level. In this manner researchers were able to maintain rations that were equal in both digestible protein and biuret levels, while changing the level of dietary concentrate consumed.

Rumen contents were withdrawn from each animal on days 0, 2, 4, 7, 10 and 14 and weekly thereafter for the 35 day test period. The biuretolytic activity of each rumen sample was measured as described above. The disappearance of biuret was measured for each sample and is reported as the average value for those animals on the same ration.

Trial 3

In this trial, the levels of concentrate and roughage were held reasonably constant while the proportion of total nitrogen present as biuret was 20, 50 or 80 percent. The level of concentrate was between 10 and 16 percent and cottonseed hulls provided the roughage source. Nine rumen cannulated sheep were divided into three groups which were fed the rations shown in Table 2. Biuretolytic activity in the rumen contents was determined on days 0, 3, 5, 7, 10, 14, 21, 28 and 35 after initiation of the trial.

Results and Discussion

Trial 1

The biuretolytic activities of the rumen contents for those animals in the first trial are reported in Figure 1. The rate of adaptation was

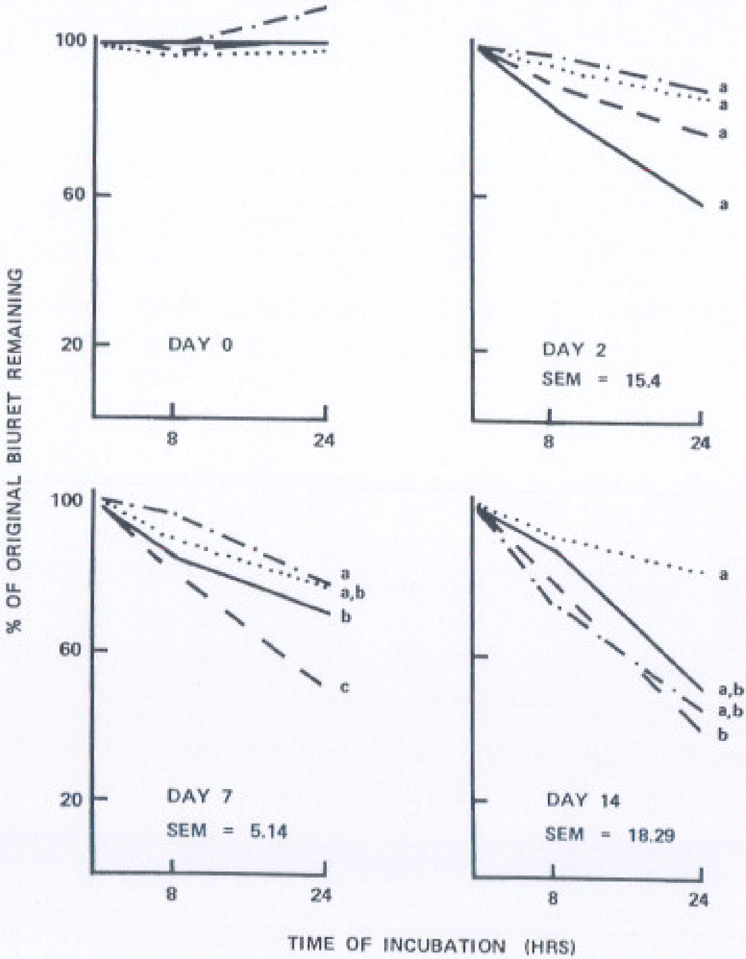

Figure 1. Biuret disappearance in rumen contents from sheep fed biuret and 20% (__), 40% (_ _), 60% (_._) or 80% (. . . .) ground corn. (Trial 1)

Table 2. Composition of Experimental Rations Fed to Sheep in Trial 3.

Ingredient	% Composition, air dry basis		
	1	2	3
Ground corn	6.53	10.91	12.92
Soybean meal	9.94	4.76	0.00
Cottonseed hulls	80.00	80.00	82.10
Biuret[1]	0.53	1.33	2.12
$NaSO_4$	0.19	0.48	0.76
Dicalcium phosphate	0.11	0.22	0.39
Limestone	0.12	0.10	0.02
T. M. salt	0.60	0.60	0.60

[1] Biuret provided 20, 50 and 80% of the total nitrogen in rations 1, 2 and 3 respectively.

such that animals on 3 of the 4 diets obtained significant activity within the first 14 days on test. Comparing this to earlier studies clearly indicated that the addition of some readily fermentable carbohydrates greatly stimulated the rate of biuret adaptation within these animals. Some response to biuret feeding was noted for all animals on day 2 and near maximum activity was obtained by day 10 or 14 for three groups of animals.

The sheep receiving either the 20, 40 or 60 percent ground corn rations apparently were better able to adapt to biuret feeding, as indicated by the loss of biuret on day 14 (Figure 1), than were those animals fed the 80 percent ground corn diet. However, it was realized that those sheep on the 80 percent concentrate were receiving less than 15 percent of their protein from biuret. On the other hand, the level of dietary biuret was progressively increased as the level of concentrate was reduced for the animals on the other diets.

To correct for this confounding effect of biuret level and concentrate level a second trial was conducted.

Trial 2

In this experiment the level of biuret was held constant while the increased concentrate fractions were achieved by adding corn starch, free of protein. The results as shown in figure 2 would indicate that, initially the higher levels of concentrate stimulated a more rapid rate of adaptation over the first 4 days on feed. However, by day 7 the situation was reversed and those animals receiving the lowest level of concentrate (20 percent) consistently demonstrated greater biuretolytic activity in their rumen contents.

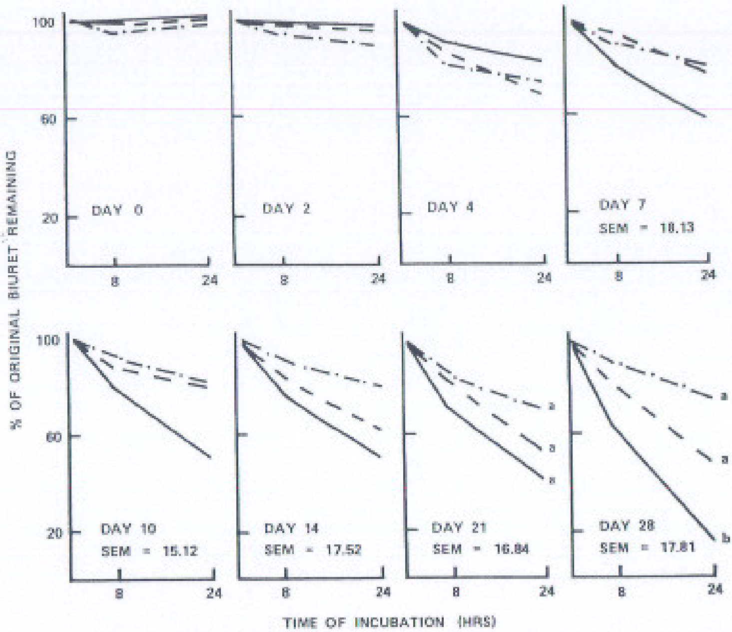

Figure 2. Biuret disappearance in rumen contents from sheep fed biuret and 20% (__), 40% (_ _), or 60% (_._) concentrate rations. (Trial 2)

The extent of biuret hydrolysis was such that by day 28 rumen contents from animals fed the 20 percent concentrate ration degraded 3 to 4 times as much biuret as that from the animals fed 60 percent concentrate and twice that of the 40 percent concentrate group.

Trial 3

In this trial biuretolytic activity began to appear at day 3 but increased slowly and did not appear to reach maximum until day 28 (Figure 3) when biuret constitued 50 or 80 percent of the nitrogen. On the other hand, when biuret was only 20 percent of the nitrogen, nearly maximum biuretolytic activity was achieved by day 7 and following that time, biuretolytic activity in this group was significantly ($P<.05$) less than in the other groups.

For all three trials the rate of adaptation was sufficiently rapid that considerable activity was achieved within the first 10 to 14 days on feed. Maximum activity was not reached until about 28 days, however. This clearly suggests that the rate of adaptation to biuret is stimulated by the

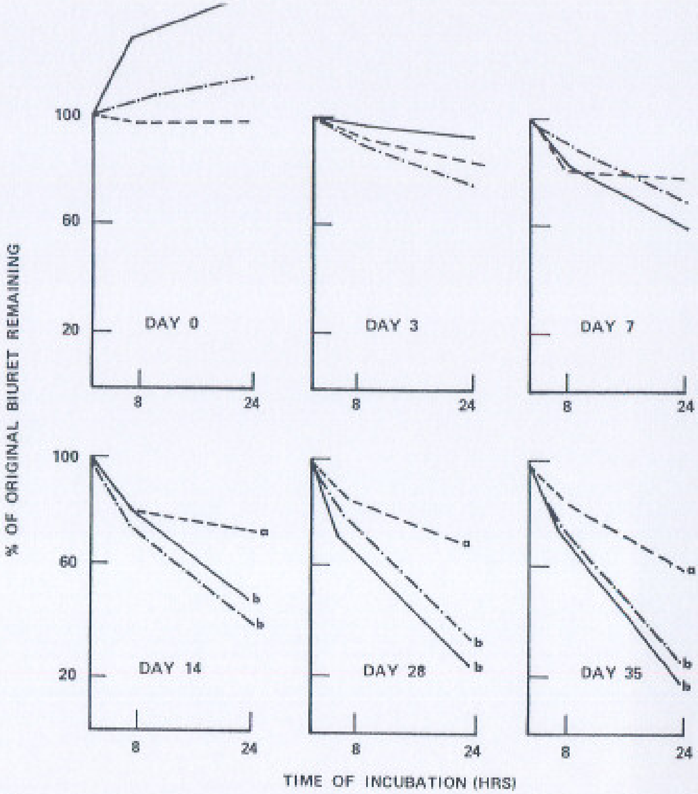

Figure 3. Biuret disappearance in rumen contents from sheep fed rations in which biuret provided 20% (_ _), 50% (_._) or 80% (__) of the total nitrogen. (Trial 3)

feeding of some readily fermentable carbohydrates. The lack of response observed for the 80 percent ground corn diet (trial 1) is presumed to be due to the low level of dietary biuret fed these animals. Trial 3 results support this theory in that biuretolytic activity was much less when biuret was only 20 percent of the total nitrogen.

Presumably, when other sources of nitrogen are present in sufficient quantity, the needs of the microorganisms are met from those sources. The results further suggest that a ration containing 20 percent ground corn (or other starch source) would be adequate for stimulating a rapid rate of adaptation to biuret. Concentrate levels above the 20 percent level substantially reduced the rate and possibly the extent of biuret utilization.

Poultry Nutrition

Protein and Energy Intake Requirements for Laying Hens

Rollin H. Thayer, G. E. Hubbell, J. A. Kasbohm, R. D. Morrison, and E. C. Nelson

Story in Brief

Ration formulation techniques were utilized to provide laying hens housed in individual laying cages with graded intake levels of protein ranging from 13 to 19 grams of protein per hen per day. The recommended protein intake requirement for laying hens has been set at 16.5 grams of protein per hen per day by the National Research Council. All of the experimental rations which were fed, regardless of ration protein level, were designed to meet the recommended energy intake level of 300 kilocalories per hen per day.

In three separate feeding trials involving this approach, it was found that there were no statistically significant differences in body weight change, percent egg production, or egg weight among the hens fed the different protein intake levels. Energy intake approximated 300 kilocalories per hen per day regardless of the energy density of the laying ration which was fed. This finding establishes the fact that the energy intake requirement of the laying hens used in this series of studies was between 275 and 300 kilocalories per hen per day, and is in line with current energy intake recommendations.

The fact that egg production was equivalent regardless of protein intake indicates that the current recommendation of 16.5 grams of protein intake per hen per day may not be valid for laying hens maintained in a caged environment. It should be noted in this connection that the amino acid content of the protein which was fed in these studies contained adequate quantities of 18 individual amino acids. Care was taken in the formulation procedure to be sure that no obvious amino acid deficiencies existed. This may account in part for the results which were obtained. Under commercial feeding conditions rations may not be formulated with this degree of attention to amino acid balance.

Introduction

Economic considerations in the Poultry Industry have brought about vertical integration and a continuing effort on the part of poultrymen to reduce production costs. Several approaches are being made in an effort to systematically reduce production costs. Among these is the use of a production system in which pullet replacements are grown in cages, and laying hens are maintained in individual laying cages during their entire productive life.

As the cage system of producing market eggs evolved, it became evident that the nutrient intake requirements of growing pullets as well as laying hens were considerably different from those required by chickens grown and maintained under floor conditions. Since laying hens and growing pullets eat until their energy requirement is met, calorie to protein ratios, and calorie to vitamin and mineral ratios become of prime importance in ration formulation, if adequate intakes of all other nutrients are to be met. This has made it necessary to first study energy intake requirements as they apply to caged pullets and hens during all stages of growth and egg production, and then to determine protein, vitamin, and mineral intake requirements in relation to these energy requirements.

The objective of this project is to obtain basic data on energy intake and the interrelationships between energy and other nutrients so that these data can be used to formulate practical nutrient intake standards for use by poultrymen under commercial production conditions in Oklahoma.

Experimental Procedure

General

Three feeding trials were conducted in a windowless caged layer laboratory on the Oklahoma State University Poultry Farm. The laboratory contains 576 individual wire cages which are arranged in twenty-four blocks with twenty-four cages per block. Each cage is ten inches wide, eighteen inches long, and is equipped with an automatic waterer, a feeder, and a feed storage container. The individual feed storage containers make it possible to weigh the feed separately for each hen, and permit the individual hen to be considered as an experimental unit.

The caged layer laboratory is equipped with an evaporative cooler, furnace, air ducts, and fans to control environmental temperature and ventilation. Environmental temperature during the three feeding trials varied from a high of 90°F. in the late summer and early fall to a low of 60°F. in the winter months. The three feeding trials were conducted over a span of three years with each feeding trial being initiated in September of one year and terminated in January or February of the following year.

The hybrid hens used in the first feeding trial were DeKalb 131s while those used in the second and third trials were H&N Nick Chicks. The age of the hens at the beginning of the feeding trials was 22 weeks for trials one and two, and 20 weeks for trial three. In all cases, the pullets were maintained in floor pens on litter during the entire growing period, and fed a series of pullet replacement grower rations developed through research at Oklahoma State University.

As the caged layer laboratory has no windows, artificial light is supplied by incandescent lights which are controlled by automatic time clocks. In all three feeding trials the laying hens received fourteen hours of continuous light and ten hours of continuous darkness until egg production reached fifty percent. At this point the length of daily light was increased by fifteen minutes each week until the laying hens were receiving seventeen hours of continuous light and seven hours of darkness each day. The laying hens remained on this lighting schedule until the end of the experiment.

Each feeding trial was divided into ten periods with fourteen days in each period. Individual body weight and feed consumption data were collected at the end of each period. In the case of the third feeding trial, body weight data were collected at the beginning of the experiment, at the end of five periods (one-half of the time on experiment), and again at the end of ten periods (when the experiment was completed). Egg production was recorded daily, and all eggs were weighed individually.

Appropriate statistical analyses were made on the data collected during each experimental period, and on the combined data for all ten periods within a given feeding trial. The following responses were involved in these analyses: feed consumption, protein consumption, energy consumption, body weight gain, percent egg production, and egg weight.

Feeding Trial 1

Eighteen experimental rations were fed in this feeding trial. Each ration was fed to twenty-four individually caged hens. The experimental rations were formulated to provide the laying hens with estimated daily protein intakes ranging from 15 to 19.25 grams in increments of 0.25 grams. All experimental rations were isocaloric and designed to provide an estimated daily energy intake per hen of 300 kilocalories of metabolizable energy.

Feeding Trial 2

Twenty experimental rations were fed in this feeding trial. Each ration was fed to twenty-one individual caged hens. The experimental rations contained four energy densities and five protein levels in a 4 x 5 factorial arrangement of treatments. The estimated daily protein intake levels per hen were 14, 15, 16, 17, and 18 grams. The daily feed intakes per hen were estimated to be 96, 106, 116, and 126 grams for the four energy densities. These estimated intakes of protein and feed were based on a daily energy intake of 295 kilocalories of metabolizable energy per hen. Dietary volume was held constant at 170 milliliters dry measure per 295 kilocalories for all of the experimental rations.

Feeding Trial 3

Twenty-four experimental rations were fed in this feeding trial with each ration being fed to twenty-four individually caged hens. These rations contained four energy densities and six protein levels in a 4 x 6 factorial arrangement of treatments. Estimated daily energy intake levels of 240, 261, 286, and 316 kilocalories of metabolizable energy were provided in the four energy densities with estimated daily feed intake at 100 grams per hen. On the basis of 100 grams of feed intake per hen per day, estimated daily intake levels per hen were set at 13, 14, 15, 16, 17, and 18 grams of protein.

Results and Discussion

Feeding Trial 1

The data for feeding trial 1 are summarized in Table 1. There were no statistically significant differences in percent egg production, egg weight, or body weight gain. Statistically significant differences in protein intake per hen per day were obtained with actual protein intake per hen per day varying from a low of 13.8 grams to a high of 18.3 grams. Differences in daily feed and energy consmption per hen were statistically significant, but were small in magnitude.

It is apparent that the hens ate until their energy requirements were met with actual energy intake per hen per day varying from a low of 266 kilocalories of metabolizable energy to a high of 317 kilocalories. Average energy intake per hen per day for all experimental rations was 288 kilocalories. Differences in feed consumption were directly related to differences in energy consumption. This is to be expected, since all of the experimental rations were isocaloric. These data indicate that 13.8 grams of protein intake per hen per day may be near the lower limit for satisfactory egg production.

Table 1. Data Feeding Trial 1.

	Experimental Ration Number																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Feed cons. per day (gm)	95	93	88	94	95	92	96	101	92	93	92	93	90	89	89	91	90	93
Energy cons. per day (Kcal)	293	288	266	281	294	286	296	313	284	287	285	289	280	276	277	280	278	288
Protein cons. per day (gm)	14.4	14.4	13.8	15.0	15.5	15.3	16.1	17.3	15.9	16.3	16.4	16.9	16.6	16.1	16.9	17.5	17.5	18.3
Percent egg production	80	78	77	78	80	79	77	79	82	77	77	80	80	80	77	79	80	79
Av. egg wt. (gm)	53	53	53	53	52	53	54	55	54	53	52	53	52	53	53	53	52	55
Body wt. gain (gm)	120	132	175	145	173	130	204	192	137	186	168	210	162	210	261	269	173	150

Feeding Trial 2

The data for feeding trial 2 are summarized in Table 2. There were statistically significant differences in feed consumption due to energy density. Actual feed consumption varied from a low of 103 grams to a high of 129 grams as ration energy density decreased. This is as expected since it has been demonstrated that the energy density of a ration exerts considerable control upon feed consumption, and hens do eat to meet a specific energy intake requirement regardless of the energy of the ration.

Actual daily protein intakes per hen were 15, 15.8, 15.1, 17.4 and 19.1 grams. These differences in actual protein intake were statistically significant. However, regardless of actual protein intake per hen per day there were no statistically significant differences in body weight gain, percent egg production, or egg weight.

Feeding Trial 3

The data for feeding trial 3 are summarized in Table 3. As had been observed previously in feeding trial two there were statistictlly significant differences in feed consumption and energy consumption per hen per day. As energy density decreased, there was an increase in feed consumption. Energy intake per hen per day varied from a low of 292 kilocalories of metabolizable energy to 326 kilocalories. Average energy consumption was 305 gilocalories per hen per day which again approximates the recommended energy intake of 300 kilocalories per hen per day. Actual grams of protein intake per hen per day were 14.1, 14.3, 14.6, 16.2, 17.3, and 17.7. As was observed in the two previous two feeding trials these differences were statistically significant and do bracket the recommended daily protein intake per hen of 16.5 grams. Again there were no statistically significant differences in either percent egg production, or average egg weight regardless of energy or protein intake. Even though there were statistically significant differences in body weight gain, all hens gained steadily during the entire experiment and the body weight gains which were made are well within the range one would expect under practical production conditions.

Conclusions and Recommendations

Laying hens apparently eat to meet a very definite daily energy intake requirement which approximates 300 kilocalories of metabolizable energy. In order to be sure that the daily intake of protein and other required nutrients are adequate, dietary levels must be related to estimated energy intake. In addition, the daily intake requirement of all nutrients must be contained in the weight and volume of feed that the

Table 2. Data Feeding Trial 2.

	Ration Energy Density				Ration Protein Levels				
	1	2	3	4	1	2	3	4	
Feed cons. per day (gm	103	110	120	129	118	116	111	114	118
Energy cons. per day (Kcal)	317	306	308	302	312	310	297	301	314
Protein cons. per day (gm)	17.2	16.6	16.5	16.3	15.0	15.8	16.1	17.4	19.1
Percent egg production	78	76	79	78	76	78	77	78	80
Av. egg wt. (gm)	51	50	52	51	50	52	51	51	52

Table 3. Data Feeding Trial 3.

	Ration Energy Density				Ration Protein Levels					
	1	2	3	4	1	2	3	4	5	6
Feed cons. per day (gm)	99	108	117	123	119	112	107	111	111	108
Energy cons. per day (Kcal)	311	308	304	295	326	306	292	304	305	294
Protein cons. per day (gm)	16.1	15.8	15.7	15.2	14.1	14.3	14.6	16.2	17.3	17.7
Percent egg production	78	80	78	77	78	76	74	81	81	79
Av. egg wt. (gm)	50	52	50	50	51	50	48	50	51	51
Body wt. gain (gm)	298	252	141	219	196	238	251	276	259	266

laying hen can and will consume under the management system being used.

The data reported in this paper indicate that the daily protein intake requirement of laying hens in cages may be less than the 16.5 grams currently recommended. Under the conditions of this series of feeding trials, ample opportunity was given to the laying hens to select daily protein intake without being restricted by excessive energy intake. The data indicate that the minimum daily intake of protein selected was approximately 14 grams. There is sufficient evidence to indicate that this level of protein intake supported egg production equally as well as did daily protein intake levels up to 19 grams.

Layer rations for use under practical feeding conditions might well be designed by poultry nutritionists to provide 14 grams of protein per laying hen per day. This would constitute a substantial saving in ingredient cost since this represents a saving in protein intake of approximately 15 percent. Care must be taken however, in the formulation procedure, to be sure that the intake requirements of 18 individual amino acids are fully met.

Dairy Nutrition

Relation of Method of Processing Sorghum Grain to Utilization by Dairy Cows

L. J. Bush, R. M. Alexander, G. D. Adams, and R. D. Morrison

Story in Brief

Since sorghum grain is widely used as a major component in concentrate mixtures for dairy cows, it is important to identify methods of processing which result in greatest improvement in its nutritive value for dairy cattle. The approach to this problem has been to first determine the particle size of ground grain utilized by cows with greatest efficiency and then to compare other processing methods with grinding to this extent.

In one trial with lactating cows, additional information was obtained to further quantify the relationship between mean particle size of ground grain and milk production. Milk yield increased as particle size decreased to approximately 475 microns, beyond which no further improvement was obtained. No differences in milk composition were observed. Although several factors have some influence on particle size of ground grain, use of a grinder screen with openings measuring 3/32 inch, or smaller, appears necessary to produce the desired product.

Steers with abomasal fistulas were used in an attempt to determine the influence of fineness of grinding on the extent of nutrient digestion in different parts of the digestive tract. Both ruminal and post-ruminal digestion of starch tended to be higher for the ration containing the more finely ground sorghum grain.

In another trial involving lactating cows, rations containing grain processed by fine grinding, steam rolling, and micronizing were compared. There was very little difference among treatments in milk production; however, milk fat test was particularly low when micronized grain was fed. Changes observed in proportions of rumen volatile fatty acids (VFA) at three hours after feeding were consistent with this lowered milk fat percentage. Only small differences were observed in digestibility of the rations containing grain processed by the different methods.

Introduction

In previous work reported last year, Bush *et al.* (1972) observed that cows fed a concentrate mixture with very finely ground sorghum grain produced more milk than cows receiving more coarsely ground grain. Increased starch digestibility, higher total concentration of rumen VFA and slightly greater weight gain were also observed in the group fed the more finely ground grain. However, a fairly wide range in particle size (expressed as geometric mean diameter) between the very finely ground and medium ground grain in that study pointed up the need for additional work to further define the relationship between particle size and production response.

Improvements in the performance of animals fed grain processed in different ways have been attributed primarily to differences in carbohydrate digestion. Recent indications are that the site and rate of starch digestion may vary due to intake by the animal and method by which the grain is processed. Karr *et al.* (1966) observed that 16 to 38 percent of the starch consumed by steers on a high concentrate diet entered the lower tract. Tucker *et al.* (1968) showed that increases in starch intake resulted in increases in the percentage of starch passing into the intestines of sheep. McNeil (1970) observed differences in the extent of ruminal digestion of starch in sorghum grain processed by different methods as follows: steam flaked, 83 percent; reconstituted and ground (5/16" screen), 67 percent; micronized, 43 percent; and dry ground (5/16" screen), 42 percent. Information on the extent of nutrient digestion in different parts of the digestive tract when rations contain sorghum grain ground to different degrees of fineness has not been reported.

One objective of these trials was to further evaluate the effect of particle size of ground sorghum grain in rations on performance of dairy cows and on the site and extent of nutrient digestion. The objective of a second phase was to compare production responses of cows fed sorghum grain processed by different methods.

Materials and Methods

Two separate trials with lactating cows have been completed. One of these dealt with the relationship between particle size of ground sorghum grain and milk yield. Another compared the responses of cows fed sorghum grain either finely ground, steam rolled, or micronized. In addition, a trial using steers with abomasal fistulas was conducted to obtain information regarding the site of nutrient digestion.

Trial 1

Mention of this trial as being in progress was made in a previous report (Designated Trial 4 in report by Bush *et al.*, 1972).

Thirty-six lactating cows (24 Holsteins and 12 Ayrshires) were used in a switchback trial involving three treatments. Comparison periods were six weeks in duration, with data from the last four weeks used for analysis and the first two weeks of each period allowed for change-over from one ration to another. Cows started the first comparison period approximately eight weeks after calving.

The experimental rations consisted of a 50:50 ratio of alfalfa hay and concentrate mixture (Table 1), with the only variable being the particle size of the ground grain. Yellow endosperm hybrid sorghum grain (NK-222) grown at the Ft. Reno Research Station was used for this experiment. Since grain comprised 70 percent of the concentrate mixture and equal amounts of concentrate and hay were fed, sorghum grain made up 35 percent of the total ration.

Variation in average particle size of the ground sorghum grain was achieved by using three different screens with openings measuring 8/64, 6/64, and 4/64 inch in diameter. Representative samples were taken at each grinding and particle size determined by the method of Ensor *et al.* (1970). Particle size of the grain designated as fine, medium and coarse ground fell within the range desired to complement the previous trial (Table 2).

Feed allowances for the cows were calculated on the basis of size, age, milk production and milk fat percentage according to 1965 NRC

Table 1. Composition of Concentrate Mixtures

Item	Trial 1 & 2	Trial 3
Ingredient		
Sorghum grain	70	70[1]
Soybean meal, 44%	10	10
Wheat middlings	10	10
Molasses, dried	7	7.5
Beet pulp	1	—
Dicalcium phosphate	1	1
Trace mineral salt	1	0.5
Urea	—	1
Chemical analysis, dry basis		
Protein (N x 6.25)	16	17
Starch	64	—
Non-starch carbohydrate	12	—

[1] Weight of ground, steam rolled, and micronized grain varied as necessary to use like amount of grain dry matter in mixture.

Table 2. Particle Size of Sorghum Grain

Items	Fineness of Grind		
	Coarse (8/64)	Medium (6/64)	Fine (4/64)
	(microns)		
Geometric mean diameter, d_{gw}	602	507	398
Geometric standard deviation, S_{gw}	1.42	1.39	1.35

requirements. The allowances were reduced by 10 percent of the initial amount at the beginning of the second and third six-week periods. Intake of nearly equal amounts of concentrate and hay was accomplished by reducing the total allowance by an appropriate amount if more than 10 percent of either hay or concentrate was refused for two consecutive days. Feeding of the planned allotment of feed was resumed as soon as the cow would consume that amount.

Milk production was recorded twice daily. Samples from four consecutive milkings each week were composited for analysis of total solids and fat percentage. The body weight of each cow was recorded on three consecutive days prior to the experiment and during the last three days of each comparison period.

Trial 2

Three abomasal fistulated dairy steers were used in a digestion trial to characterize digestion of nutrient components of the same rations fed to the lactating cows in Trial 1. A 3 x 3 rotational (Latin square) design provided for each animal to be fed each ration in turn according to a pre-determined sequence. Comparison periods were three weeks in duration. Feed allowances sufficient for maintenance and approximately 2.0 lb. gain per day were calculated using net energy and digestible protein requirements for growing cattle (Lofgreen and Garrett, 1968).

Apparent ruminal and total digestion of nutrient components were determined by using chromic oxide as an external indicator during the last two weeks of each comparison period. Abomasal and fecal samples were collected twice daily on the last five days of each period.

Trial 3

In this trial, 24 lactating cows (18 Holsteins and 6 Ayrshires) were used to compare rations containing finely ground, steam rolled, and micronized sorghum grain. Average particle size (geometric mean diameter) of the finely ground grain was 285 microns. The steam rolled grain was processed by steaming for 20 to 30 minutes and afterwards rolling in a manner to produce minimal flattening of the kernels. The micronized material was prepared by vibrating the grain on a heated metal plate until thoroughly heated and then rolling in a manner to produce a product having approximately 24 pounds test weight per bushel.

Ration allowances were calculated according to the 1971 NRC energy requirements for dairy cattle. Rumen samples were taken at three hours after the morning grain feeding for determination of the proportion of ruminal volatile fatty acids (VFA). Digestibility of ration components was determined by use of chromic oxide as an external indicator during the last 12 days of each comparison period. Other experimental conditions were the same as described for Trial 1.

Results and Discussion

Effects of Fineness of Grinding

Several cows required a few days to adjust to the concentrate mixtures with very finely ground grain, but consumed it readily thereafter. Intakes of concentrate mixture and hay were nearly equal as planned (Table 3).

Cows fed the concentrate mixtures with medium and fine grain produced significantly more milk than those receiving the coarsely ground grain. Milk composition was essentially the same for all groups. Average feed intake was slightly more, i.e., .3 lb./day, when the cows were fed fine or medium ground grain. However, higher milk yield of cows fed these rations cannot be attributed to this small difference in intake because the net energy value of this amount of feed would be insufficient to account

Table 3. Responses of Cows Fed Sorghum Grain Ground to Different Degrees of Fineness

Item	Coarse	Medium	Fine
Feed intake, D.M. basis			
Hay, lb./day	17.1	17.3	17.3
Concentrate, lb./day	17.9	18.0	18.0
Milk production			
Daily yield, lb.	42.2[a]	43.2[b]	43.4[b]
Fat, %	3.97	3.95	3.93
Non-fat solids, %	9.49	9.51	9.53
Weight change			
Gain per 6-wk., lb.	19.2	21.8	20.8

ab Means with different letters significantly different ($P < .05$).

for the difference in milk production. Moreover, the difference in energy intake could be equated with the energy value of the additional weight gain by cows fed more finely ground grain.

Considering the responses of cows in this trial along with the results obtained previously (Figure 1), it appears that a curvilinear relationship may exist. Projecting an increase in milk yield with decreasing particle size of ground sorghum grain to a point beyond which yield levels off appears to allow the best interpretation of both sets of data. With this assumption, it appears that maximum milk yield is reached when average particle size is around 475 microns. The actual particle size produced when sorghum grain is ground is influenced by several factors such as moisture content of the grain and flow rate, as well as screen size. Nevertheless, it appears that a screen with 6/64 inch, or smaller, openings would generally need to be used to grind sorghum grain for maximum utilization by dairy cows.

Apparent digestibility of ration components by dairy steers tended to be higher when the concentrate mixture contained finely ground grain, although the differences were not statistically significant ($P>.05$). In particular, starch digestion tended to increase with decreasing particle

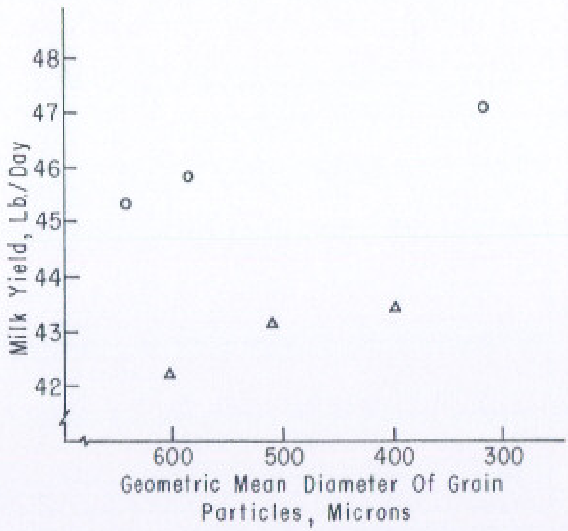

Figure 1. Average daily milk yield in relation to fineness of grinding sorghum grain. Points designated by "O" represent data from trial previously reported (Bush et al., 1972); points designated by "△" represent data from present study.

size of ground sorghum grain which was in agreement with previous observations on digestibility by lactating cows (Bush *et al.*, 1972). Apparent ruminal digestion coefficients for crude protein, either extract and non-starch carbohydrate were negative (Table 4). Poor sampling of abomasal contents of one steer due to improper placement of the abomasal fistula appeared to be responsible for these discrepant values. Exclusion of the data on this steer resulted in positive values in all treatment groups for the nutrient components. Linear increases in ruminal starch digestion in relation to decreasing particle size approach statistical significance ($P<.08$).

Average starch intake by the steers on the three rations was 2.08 lb./day (Table 5). Starch in the more finely ground sorghum grain tended to have higher digestibility both in the rumen and intestines. A high percentage of the starch in all the rations was digested in the rumen. Additional work would be needed to definitely establish whether or not there are real differences in ruminal starch digestibility that account for the observed differences in animal performance.

Comparison of Methods of Processing

There was very little difference in milk yield of cows fed rations containing sorghum grain processed by fine grinding, steam rolling, or micronizing (Table 6). The most notable difference among treatments was in regard to milk fat percentages. For unknown reasons, fat test was lower when cows were fed finely ground grain than when fed steam rolled grain.

Table 4. Apparent Digestibility Coefficients of Ration Components

Component	Ration treatments					
	Coarse		Medium		Fine	
	(%)					
Ruminal Digestion						
Dry matter	10.7[1]	(38.5)[2]	31.2	(43.0)	16.9	(29.9)
Crude protein	−31.3	(18.1)	− 7.7	(21.6)	−11.2	(1.4)
Ether extract	−25.5	(7.1)	− 9.1	(1.9)	8.0	(7.4)
Starch	80.8	(83.4)	84.5	(88.4)	87.2	(89.0)
Non-starch CHO	− 3.0	(28.2)	17.4	(38.6)	5.7	(14.8)
Total Digestion						
Dry matter	52.3		52.0		57.5	
Crude protein	54.3		51.8		58.7	
Ether extract	53.0		48.6		64.4	
Starch	92.4		94.3		95.5	
Non-starch carbohydrate	33.9		35.6		41.7	

[1] Average of three observations.
[2] Mean digestion coefficient based on two steers; one steer sampled poorly due to placement of fistula.

Table 5. Starch Intake and Digestion at Different Sites Along the Digestive Tract

	Ration treatment		
	Coarse	Medium	Fine
Mean starch intake, lb./day	2.08	2.08	2.08
Apparent digestibility in rumen, %	80.8	84.5	87.2
Starch entering intestine, lb./day	.40	.32	.27
Apparent post-ruminal digestibility, %	60.8	63.0	65.3
Total starch digested, lb./day	1.92	1.96	1.99
Apparent total digestibility, %	92.45	94.28	95.52

Table 6. Feed Intake and Milk Yield of Cows

	Method of processing		
Item	Ground	Steam rolled	Micronized
Feed intake			
Grain, lb./day	18.7	18.9	18.3
Hay, lb./day	18.7	18.7	18.3
Milk production			
Milk yield, lb./day	59.2	59.4	58.7
Fat, %	2.8[a]	3.0[b]	2.6[c]
Non-fat solids, %	8.6	8.6	8.6
SCM, lb./day	48.6	49.9	47.3

abc Means with different superscript significantly different ($P < .05$).

The fat content of milk produced by cows fed finely ground grain in previous trials was not particularly low, and no differences in fat test have been associated with fineness of grinding.

The depression in fat test when micronized grain was fed was consistent with the observed changes in proportions of rumen VFA (Table 7). In particular, a lower percentage of acetic and increased propionic acid have been observed by various workers (e. g., Balch *et al.*, 1955; Shaw *et al.*, 1959; Baumgardt, 1967) when milk fat test was depressed. Whether sorghum grain can be micronized in a manner to produce some degree of starch gelatinization and consequent rumen VFA proportions commensurate with normal milk fat percentage remains to be determined.

There was very little difference in overall digestibility of the rations used in this trial (Table 8). Small differences in digestibility of single components, e. g., protein, in favor of the micronized grain were not sufficiently large to have an appreciable effect on total dry matter or organic matter digestibility. The relatively high digestibility coefficients observed

Table 7. Molar Percentages of Rumen VFA

Acid	Method of processing		
	Ground	Steam rolled	Micronized
Acetic	68.0[a]	64.9[a]	58.9[b]
Propionic	21.1[a]	23.3[ab]	27.3[b]
Butyric	8.9[a]	9.6[a]	11.6[b]
Iso-valeric	1.0[a]	1.1[a]	0.7[b]
Valeric	1.0[a]	1.1[a]	1.5[b]

ab Means with different letters significantly different ($P < .05$).

Table 8. Apparent Digestibility of Ration Components

Component	Method of processing		
	Ground	Steam rolled	Micronized
	(%)		
Dry matter	80.4	80.3	81.8
Protein	81.5[ab]	81.2[b]	83.2[a]
Organic matter	81.9	82.1	83.5

ab Means with different letters significantly different ($P < .05$).

in this trial were attributed to the fact that the forage portion of the ration was of very high quality as evidenced by 24 percent total protein content on a dry basis.

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Dairy Physiology

The Effects of Exposure to Ambient Temperature on Sperm Cells Stored in Straws

M. E. Wells, P. J. Hefley and T. L. Bright

Story in Brief

Several artificial inseminations in the past two years have converted partially or completely to the use of either 1/4 cc. or 1/2 cc. straws as their method of storing semen. This particular method of storage has been used in Europe for a few years and the movement of semen of exotic bulls into this country in straws has stimulated our artificial insemination industry to attempt to use this particular method of semen storing.

Little is known concerning how straws should best be stored and thawed. It is known that improper handling of ampuls can significantly decrease the percent live cells that are present in an ampul of stored semen. The time element concerning how long an ampul of semen can be safely exposed before returning it to the nitrogen tank has been well established. Such parameters have not been established for handling straws. It was the intent of this research to establish the safe handling procedures necessary for satisfactory use of semen stored in straws.

Semen was collected from four bulls on two different occasions and stored in 1/4 cc. straws. These straws were exposed to room temperature for 10-second intervals and then returned to the nitrogen tank. Straws were exposed for a maximum of ten 10-second exposures and then thawed and evaluated for the speed of movement of the cells and the percent of the cells that were showing progressive mobility.

There was little doubt that even one 10-second exposure had a significant effect ($P<.01$) in lowering the percent live cells in the stored straws. Approximately 15 percent of the live cells were lost after exposing the straws for one 10-second interval and then returning the straw to the tank. After the third 10-second exposure, the percent live cells had decreased to less than half of the original percentage. This indicates that the sperm cells stored in straws cannot be exposed to ambient temperature and returned to the nitrogen tank as has been typical of cells in ampuls. Poor fertility can obviously result from careless handling of semen stored in 1/4 cc. straws.

Introduction

Since about 1956, the artificial insemination industry has utilized the glass ampul as the preferred method of freezing, storing and delivering semen to the artificial insemination customer. This particular system has worked well and satisfactory fertility has been typical throughout the industry from the use of the ampul. For the past several years, several European countries have converted to extensive use of the straw as the preferred method of semen packaging.

Several reports (MacPherson, et al, 1966; Carpenter, 1971; MacPherson and Penner, 1972; Day, 1972; Bean, 1972) utilizing organizational technicians have indicated some small advantage for straws in conception rate, usually one to two percent. Other advantages have been cited, namely, greater quantities of semen can be stored in the same space occupied previously by ampuls and better post-freeze recoveries are typical with semen stored in straws.

A big percentage of the artificial inseminations in this country are done by personnel other than technicians hired directly by the artificial insemination stud. There is much greater opportunity for mistakes to be made by people who will not be typically as well trained or controlled as would be a technician hired by the bull stud. No controlled research has been published in which straws were purposely exposed to the typical mistakes that may be made in the field. This experiment was conducted to measure the influence of routine mistakes that could be made on the farm in using straws.

Previous research with semen stored in ampuls indicate that an ampul can be exposed safely to room temperature for 10 to 12 seconds and returned to the nitrogen tank without significant loss of live sperm cells. Exposure to room temperature for one minute and then returning to the tank has resulted in significant loss of live sperm cells stored in the ampul. This research is an attempt to define the effect of length of exposure to room temperature on cells stored in ¼ cc. French straws.

Procedure

Semen was collected from four dairy bulls on two different occasions and stored in ¼ cc. French straws for use in this study. All bulls were housed and handled similarly and were on routine maintenance rations. Semen was collected and initially evaluated for the percent live cells and the rate of movement of the cells. Each ejaculate was then diluted with egg yoke-citrate-glycerol extender to yield 20 million live cells per straw prior to freezing. The straws were filled, plugged and then placed in 5°C water for approximately three hours. The straws were then placed on a freezing rack and placed in a MVE Model CBF-21 vapor freezing unit at a point above the nitrogen where the vapor temperature was −130°C. The cells were left at this level for seven minutes and then placed in the liquid nitrogen for transfer into the storage unit. Three straws on each ejaculate of each bull were then thawed in a 35°C water bath and evaluated for the percent live cells and the rate of movement of the cells.

These observations represented the degree of recovery of the cells post freeze with no treatment imposed. The effect of repeated exposure to room temperature was evaluated using from one to ten 10-second exposures to room temperature. After each individual exposure, the three straws in each ejaculate for each bull were returned to the nitrogen tank for at least one minute before thawing and evaluating for the rate of motility and the percent of live cells.

Treated straws were also thawed in 35° C water for one minute and then placed on a warm microscope slide for evaluation purposes.

Results and Discussion

Table 1 shows the average quality of the ejaculates used in this study for both pre-freeze and post-freeze motile cells. The average pre-freeze quality was 85 percent live cells. The average quality post-freeze with no treatment imposed was 55 percent live cells. This gives an average post-freeze recovery rate of 65 percent. Table 1 also presents the average recovery rate that has been experienced in ampul studies with these particular bulls although ampuls were not stored from these ejaculates.

The average recovery rate that we have experienced with these bulls before with semen stored in ampuls was 45 percent. It has been our experience as well as others, that semen stored in straws typically will have a better recovery rate than will semen stored in ampuls. This is one

Table 1. Comparison of Percent Motile Cells Pre-Freeze and Post-Freeze

Method of Storage	Pre-Freeze	Post-Freeze	Recovery Rate
	%		
Straw	85	55	65
Ampul	85	38	45

of the advantages that straw storage has over ampul storage in that better utilization of the bulls can be obtained with straws.

Figure 1 presents the average effect of multiple exposure of straws to room temperature. Successive exposure of straws to roow temperature results in a drastic decrease in the percent live cells. It is significant to note that the first few exposures take a heavy toll of the percent live cells in the straws. Figure 1 illustrates that with just one 10-second exposure an average of 25 percent of the live cells in the straw was lost. This alone could result in a significant lowering of fertility of

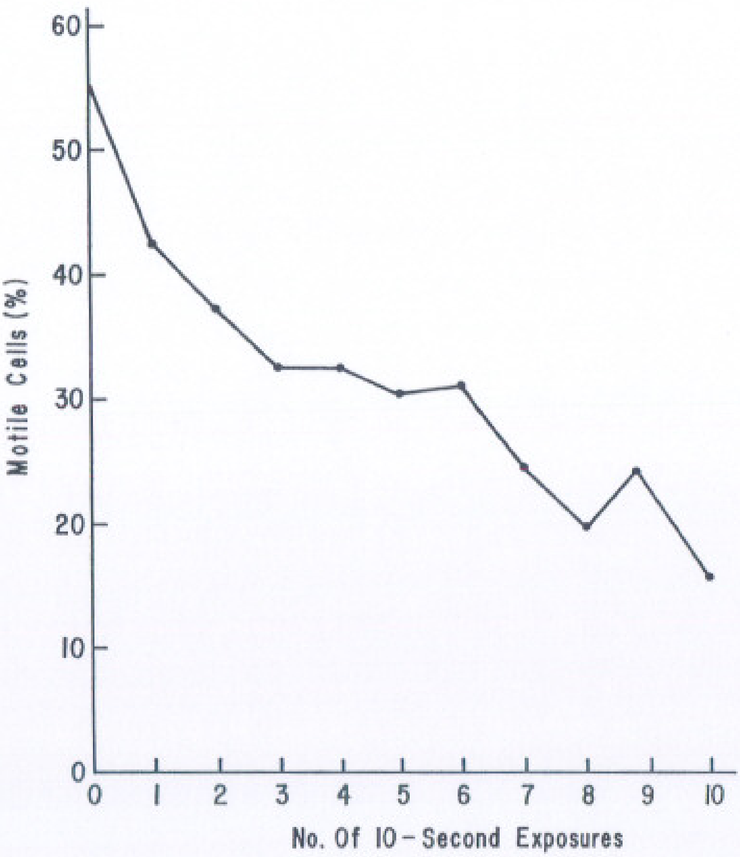

Figure 1. Effects of Exposure to Room Temperature on Percent Motile Cells in Straws.*

* Each point is the average of 4 bulls, 2 ejaculates/bull, 3 straws per ejaculate.

the cells in the straws as a result of the decreased usable sperm cell population. As you continue to expose the straws at 10-second intervals, you continue to lose more live cells. At the end of the second exposure, over 30 percent of the live cells have been lost, and at the third exposure 40 percent of the live cells have been lost. It is apparent that with the thin dimension of the straw, rapid thawing can apparently occur in just one 10-second exposure and its subsequent refreezing then results in highly significant losses of live sperm cells. The practical interpretation of this is that we do not have the latitude for making mistakes with straws that we have with ampuls.

This information suggests that a straw should not be removed from the tank for any purpose except to thaw it enroute to ultimately being placed in the cow's reproductive system. This means that we must have adequate maps of our semen storage tanks so that one can readily locate the desired animal without resorting to pulling the straws out of storage to read the name or number and then return the straw to the tank. Mishandling of the straws in the manner described here will surely take away any advantage that might potentially be there for breeding our cattle with straws.

Figure 2 illustrates another deleterious effect that multiple exposures to room temperature can have. The relative strength of the cells was measured throughout this trial and is indicated by the rate of their motility. As can be seen in Figure 1, the cells in the straws started out with a very acceptable rate of motility. However, as the straws were exposed to increasing numbers of 10-second exposures, the strength of the cells apparently failed. Again, a practical interpretation of this means that the repeated exposures apparently weakened the cells. Although we did not collect fertility data in this study, other data would suggest that when cells are so weakened, fertility of the cells would be lessened.

The data presented indicates strongly that serious mistakes can be made as we attempt to utilize straws in implementing artificial insemination programs in our livestock herds. The great damage is apparently done by the stress incurred by the partial thawing and refreezing that occurs when straws are removed or exposed to room temperature and then returned to the nitrogen tank. In this process, we lose a large percentage of the live cells and undoubtedly have a significant effect on the potential fertility of the stored cells.

The conclusions in this report about exposing cells stored in straws to room temperature agree quite well with similar research conducted on cells stored in ampuls (Pickett, et al, 1961). Other research is presently in progress seeking to better define how semen stored in straws should be handled.

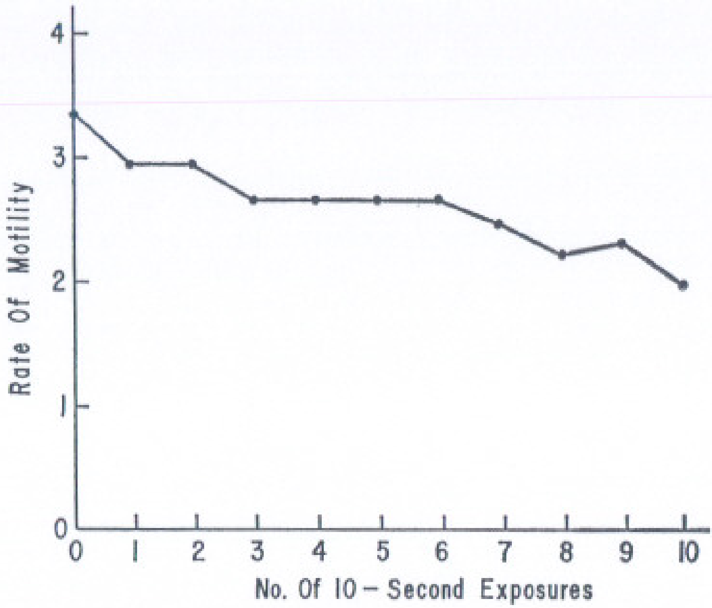

Figure 2. Effects of Exposure to Room Temperature on Rate of Movement of Cells in Straws.*

* Each point is the average of 4 bulls, 2 ejaculates/bull, 3 straws per ejaculate,

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The Role of the Acrosome in Prediction of Fertility

M. E. Wells, L. G. Jay, I. Elliott and D. Holbert

Story in Brief

It has been the desire of reproductive physiologists, veterinarians and bull studs to find a reasonably reliable indicator of the fertility of bulls. This has been a disappointing search for several years. Some indicators of ejaculate quality have been used for years to grossly separate and identify bulls or ejaculates of "acceptable" quality. No single indicator is highly indicative of fertility.

Research in recent years has developed means to ascertain the morphology of the acrosome which is a cap-like structure over the anterior half of the sperm nucleus. Our research measured several ejaculate characteristics, including the acrosome state, and utilized these in attempting to build a fertility prediction equation. The observations summarized in the report indicate that several pre-freeze and post-freeze ejaculate characteristics can be combined to give a reasonable prediction of fertility.

Introduction

The reports of many researchers over several years have shown several ejaculate characteristics to be associated to some degree with fertility of the male. (Lasley and Bogart, 1943; Shaffer and Almquist, 1949; Erb et al, 1951; Bishop, et al, 1954; Munroe, 1961). However, progress in developing a system for predicting fertility has been slow because no single measurement or series of measurements has sufficed in accurately evaluating fertility (Saacke, 1970).

It is known that the acrosome is important in the fertilization process, however, the exact mechanisms which are regulated or moderated by acrosome function are not well defined. Research on the acrosome has been renewed in recent years by the development of means that allow the morphology of the acrosome to be examined (Saacke and Marshall, 1968; Wells and Awa, 1970). Recent reports (Saacke, 1970; Saacke, et al, 1968; Saacke and White, 1972) indicate that the state of the acrosome in a population of cells may be a useful indicator of the potential fertility of that population.

The objective of this study was to evaluate a number of sperm characteristics and determine their significance in prediction of fertility, and develop a fertility index utilizing these characteristics.

Procedure

Forty-two Holstein bulls in the progeny test unit of American Breeders Service, De Forest, Wisconsin, were utilized in this study. All bulls were approximately one year of age at the time of initial ejaculate collection, were housed and handled similarly, and were fed a routine growth ration throughout the conduct of the study.

Two ejaculates were collected and processed for freezing once weekly from the bulls until 520 ½cc ampules, containing 7 to 13 million live sperm, were obtained. Five to eight collections were typically required to get the desired number of ampules in storage. This frozen semen was randomly distributed to cooperating herds across the United States, however, no bull was to be used more than four times in any given herd. It was projected that data on 150 to 200 services to each bull would result from the described distribution.

Several measurements were made on sperm characteristics of each ejaculate, both pre-freeze and post-freeze. Percent live cells was estimated microscopically and by slides differentially stained by the method of Hancock (1952). Two hundred sperm cells were examined per slide to determine the percent live. Acrosome characteristics were determined from 200-cell-counts on differentially stained smears (Wells and Awa, 1970). Cells were first classified as normal or abnormal morphology and then as aged or non-aged acrosomes within these classifications. From the slides prepared, the following pre-freeze and post-freeze percentages were determined for each ejaculate:

1. Live cells
2. Aged acrosomes
3. Normal morphology
4. Normal cells with aged acrosomes
5. Normal cells with nonaged acrosomes
6. Abnormal cells with nonaged acrosomes
7. Abnormal cells with aged acrosomes.

A microscopic estimate of percent motile cells was made immediately post-freeze and one month post-freeze. Ampules were thawed in 5° C. water for 5-7 minutes and a small drop of semen was placed on a slide, warmed to 37° C. and the percent motile cells was estimated to the nearest whole percent.

These 16 variables were analyzed to determine (1) their contribution to the fertility of the animal, and (2) the relative weight that should be given to the significant variable in computing an estimate of fertility.

Results and Discussion

Approximately 520 ampules of semen per bull were distributed across 60,000 cooperating herds by ABS. There was a total of 5,976 first services with an average of 142 services for each of the 42 bulls. The number of services ranged from a low of 110 to a high of 182 per bull. Fertility on a 60-90 day non-return to first service basis for the 42 bulls ranged from 53.3 to 82.6 percent with an average across all bulls of 70.7 percent.

Table 1 presents a summary of the average pre-freeze and post-freeze evaluations of sperm characteristics measured in this study. It will be observed, first of all, that the average percent live sperm decreased from 81.5 percent pre-freeze to 32.5 percent post-freeze. This is in good agreement with the industry observation that over half the initially live cells are lost in the freezing process. A comparison of the balance of the pre-freeze and post-freeze changes is presented in Table 2. The percent normal cells decreased as did the normal cells with nonaged acrosomes and the overall percentage of nonaged acrosomes. Or, freezing decreased the percent live cells and percent normal cells and increased the degree of aging noted in the ejaculates. It is interesting to note that the percentage of normal cells with aged acrosomes remained unchanged.

Table 1. Overall Means ($\overline{X}$) and Standard Deviations (S.D.) for the Spermatozoan Characteristics Studied

Characteristic	$\overline{X}$ (%)	S.D. (%)
Pre-freeze Evaluation		
Live Spermatozoa	81.5	6.4
Aged Acrosomes	34.7	10.9
Normal Spermatozoa	74.1	10.3
Normal Cells with Aged Acrosomes	21.1	8.9
Normal Cells with Nonaged Acrosomes	53.0	10.8
Abnormal Cells with Nonaged Acrosomes	11.9	6.7
Abnormal Cells with Aged Acrosomes	13.6	5.8
Nonaged Acrosomes	65.0	11.3
Post-freeze Evaluation		
Motility (O-storage time)	32.5	7.3
Motility (1 month storage time)	31.2	5.3
Aged Acrosomes	47.9	12.4
Normal Spermatozoa	59.1	15.3
Normal Cells with Aged Acrosomes	20.2	3.9
Normal Cells with Nonaged Acrosomes	38.9	14.3
Abnormal Cells with Nonaged Acrosomes	11.9	4.4
Abnormal Cells with Aged Acrosomes	27.7	13.1
Nonaged Acrosomes	50.8	14.4

Table 2. Influence of Freezing on Various Sperm Cell Characteristics

Sperm Cell Characteristic	Mean-% (243 collections)		
	Pre-freeze	Post-freeze	Change
Normal Cells	74.5	60.2	−14.3
Aged Acrosomes	34.2	48.2	+14.0
Normal Cells with Aged Acrosomes	20.8	20.5	− 0.3
Normal Cells with Nonaged Acrosomes	53.7	39.7	−14.0
Abnormal Cells with Nonaged Acrosomes	11.8	12.0	+ 0.2
Abnormal Cells with Aged Acrosomes	13.4	27.7	+14.3
Nonaged Acrosomes	65.5	50.9	−14.6

Table 3 lists the ten variables, in order of importance, that added significantly ($P<.05$) to the prediction of 60-90 day non-return rate. Progressive motility post-freeze and the morphology of cells pre-freeze are indicated to be two of the more important variables in the prediction of fertility. This is in agreement with the literature which for years has indicated motility and morphology to be important aspects of semen evaluation.

In addition to these characteristics, it is evident from Table 3 that the state of the acrosome should also be considered in semen evaluation. Five of the ten variables that add significantly to the prediction of fertility involve the acrosome. This indicates that the acrosome is too important in semen evaluation to be ignored and should play an important role in routine fertility evaluation. Table 3 also shows that certain pre-freeze characteristics contributed significantly to the prediction of fertility. The percentage of normal cells pre-freeze with aged acrosomes is a highly important measurement which does not change significantly with freezing (Table 2). The total percentage of acrosomal aging in the initial ejaculate is also important. The percentages of normal cells and live cells pre-freeze also add significantly to prediction of fertility.

It should be realized that the last three pre-freeze characteristics mentioned change appreciably during freezing and post-freeze measurements of these characteristics are also present in the list of significant components of the prediction system (Table 3).

The variables listed in Table 3 were utilized in various combinations to determine the precision with which fertility was predicted. These results are summarized in Table 4. When all ten variables were utilized, 86 percent of the bulls observed to be above or below average were

Table 3. Variables Having a Significant Effect in Prediction of Fertility*

1. Post-freeze motility ("0"—storage time).
2. Pre-freeze normal cells with aged acrosomes.
3. Pre-freeze normal cells.
4. Post-freeze motility (1 month storage time).
5. Post freeze aged acrosomes.
6. Post-freeze nonaged acrosomes.
7. Pre-freeze aged acrosomes.
8. Pre-freeze live cells.
9. Post-freeze normal cells with aged acrosomes.
10. Post-freeze normal cells.

*P<.05 for all variables.

computed to be so. The combinations of three, four or six variables were less precise in the prediction resulting, ranging from 74 percent to 79 percent.

Table 4 presents another way to evaluate the predictor system. The percentage of bulls where the computed fertility was within 5 percent of the observed value ranged from 71 percent to 76 percent with ten variables being somewhat superior to the other combinations. When the limit was increased, 93 percent to 95 percent of the computed values were within 7 percent of the observed fertility. The weighting factors utilized in the above combinations of variables are presently being refined and will be published in detail at a later date.

Table 4. Summary of Predictions of Fertility

Combinations of variables	Bulls classified correctly as above or below average	No. bulls where computed value was within 5% of observed	No bulls where computed value was within 7% of observed
Combination 1 (All 10 variables)	$\frac{36}{42} = 86\%$	$\frac{32}{42} = 76\%$	$\frac{39}{42} = 93\%$
Combination 2 (3 variables)	$\frac{33}{42} = 79\%$	$\frac{30}{42} = 71\%$	$\frac{40}{42} = 95\%$
Combination 3 (4 variables)	$\frac{31}{42} = 74\%$	$\frac{31}{42} = 74\%$	$\frac{39}{42} = 93\%$
Combination 4 (6 variables)	$\frac{31}{42} = 74\%$	$\frac{31}{42} = 74\%$	$\frac{39}{42} = 93\%$

Results from this study strongly indicate that the state of the acrosome is an important aid in trying to predict the potential fertility of a bull. At this time it appears that pre-freeze and post-freeze determinations of motility, morphology and state of the acrosome are all important spermatozoan characteristics in the prediction of fertility.

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Morphology of Two Yeast Species Grown In Cottage Cheese Whey

Diana Halter and J. B. Mickle

The Story in Brief

The purpose of this study was to determine how the cellular morphology of *Saccharomyces fragilis* (NRRL Y-1156) and *Rhodotorula gracilis* (NRRL Y-1091) changed when grown in cottage cheese whey. Previous work from this laboratory had shown that these yeasts can be used to remove the lactose from cottage cheese whey, thus reducing the BOD (biological oxygen demand) and making disposal much simpler. It was thought that the organisms could be harvested along with the protein remaining in the cheese whey and sold as feed. If so, it would be advantageous to harvest the organisms at the stage of maximum cell size and number. These yeasts may be useful as a human food or an animal feed. In certain feeds, the amount of energy is of importance; thus, it was of interest to determine when these organisms reached a high fat content.

Each yeast species was grown in cottage cheese whey under optimum conditions as had been determined in this laboratory. Photomicrographs were taken of the cells at regular intervals during the growth trial. These pictures indicated that the *S. fragilis* cells reached their maximum size in approximately 7-12 hours and maximum cell numbers in approximately 25 hours. The dimensions of *S. fragilis* yeasts ranged from 3.8-5.3 x 2.4-3.7 u.

The numbers of *Rh. gracilis* cells reached a first maximum when the lactose in cheese whey was used up at approximately 66 hours. After adding 5 percent sucrose to the medium, the cells continued to grow and started to show fat vacuoles. The cell numbers reached a second maximum when the first 5 percent sugar addition was gone at the end of 90¼ hours. They reached a third maximum after a second addition of sucrose at the end of 96 hours. The cell walls of *Rh. gracilis* progressively thickened as the cells aged.

Although research of literature has failed to disclose pictures of either of these yeast species grown on cheese whey, the size and morphology was similar to that reported when the organisms had been grown on other media.

Introduction

The disposal of cottage cheese whey is a major problem for the industry since this material has a relatively high biological oxygen demand and many cities will not allow this material to be dumped into their sewers. Over 60 percent of the BOD in cottage cheese whey comes from lactose (milk sugar). Thus, removing the lactose prior to disposing of the whey removes a major portion of the organic material and simplifies the disposal problem.

Previous work in the OSU Dairy Foods Research Laboratory had shown that two yeast species, *Saccharomyces fragilis* and *Rhodotorula gracilis,* would use lactose as a growth material, thus removing it from the whey and reducing the BOD 60 percent or more during the process. In connection with this work, it was of interest to know when the cells reached their maximum size and, in the case of *Rh. gracilis* (a fat-producing yeast species), when a high fat content could be obtained. This information was needed because the larger cells are easier to separate from the whey and the higher the fat content in the organism, the more energy it contains and the more value it has for certain feed stuffs.

Although the cellular morphology of both of these species had been studied (2), research of literature failed to disclose pictures of these yeasts grown on cottage cheese whey.

Procedure

Pure cultures of *S. fragilis* and *Rh. gracilis,* the two yeast species studied in these experiments, were routinely carried on lactose-agar slants. *S. fragilis* is a lactose fermenting yeast; however, the original strain of *Rh. gracilis* could neither ferment nor assimilate lactose (2). Thus, it became necessary to adapt it for our use. After eight successive transfers on lactose-agar slants (a technique used by Neilsen and Nilsson (3) to adapt these yeasts to xylose), *Rh. gracilis* was adapted to the use of lactose (and whey) as a growth medium.

To prepare the *S. fragilis* for growth trials, a loop of pure culture was transferred from a slant to a broth containing 2 percent lactose, 1 percent peptone, and 0.1 percent yeast extract. After the yeasts exhibited rapid growth, a 10 percent innoculation of this "starter" broth was added to whey for the actual growth trials to obtain the *S. fragilis* yeast cells needed for observation of morphological changes (1). The *Rh. gracilis* yeasts also were prepared in the above manner. When sugar determination indicated that the lactose in the whey had been exhausted by the *Rh. gracilis* yeasts, 5 percent sucrose was added to the whey for fattening them. After this sucrose was exhausted, 5 percent additional sucrose was again added. The temperature for both species was maintained at 95 ± 5° F (35± 3° C) during the growth period. Photomicrographs taken of fresh cells compared with frozen and thawed ones had revealed that freezing and thawing the cells did not appreciably change cellular morphology. Thus, the samples which were taken at intervals were frozen until analyzed. Later, photomicrographs were taken of wet mounts from the thawed samples.

A 1:20 dilution of each sample was prepared for the wet mount using a blood diluting pipette with distilled water and methylene blue stain as diluents. The methylene blue stain was routinely used as a cell stain, but selected samples of *Rh. gracilis* also were stained with Sudan Black B to determine if fat was present in the intracellular bodies.

Results and Discussion

Photomicrographs of *S. fragilis* indicated that cellular growth and size increases closely paralleled the growth curve (Figure 1). The morphology of the cells during the growth period was primarily ellipsoidal or cylindrical. The dimensions of these organisms ranged from 3.5-5.3 x 2.4-3.6 u excluding buds. The cells reached maximum size in about 7-12 hours and maximum cell numbers in approximately 25 hours. These yeasts usually occurred as single or budded cells, and multilateral budding was observed (Figures 2, 3, 4, and 5). The pictures of *S. fragilis* grown on cheese whey showed that their morphology and size were similar to cells previously described and photographed by researchers when these organisms were grown on other media (2).

The increase in size of *Rh. gracilis* yeasts closely followed the growth curve (Figure 6) drawn from cell count data of this trial. During the growth period, photomicrographs showed both ellipsoidal and oval cells (Figures 7, 8, 9, and 10) which were typical shapes described by other investigators when the yeasts were grown on different media (2). Some of the cells were observed to have a cytoplasm which stained in an hourglass pattern similar to that found by Ruinen and Deinema (4).

There were three maximum points on this *Rh. gracilis* curve (Figure 6). The first occurred after 66 hours when the organisms had apparently used up most of the lactose and protein in the original whey media. At this time the cells had an average size of 5.2 x 3.0 u (Figure 11). Points marked "S" on the growth curve refer to the times at which 5 percent sucrose was added to the media. Prior to the addition of sucrose, the cells appeared short and narrow; whereas, when they started growing, they were longer with an average size of 6.4 x 3.0 u (Figure 12). At the time Sample "G" (Figure 13) was taken, just before the second sucrose feeding, cell numbers had increased to 635 x 10^6 and the average cell size was 6.4 x 4.2 u. Six hours later, when the cells had again started to grow (Sample "H", Figure 14), the average cell size was 7.0 x 4.4 u.

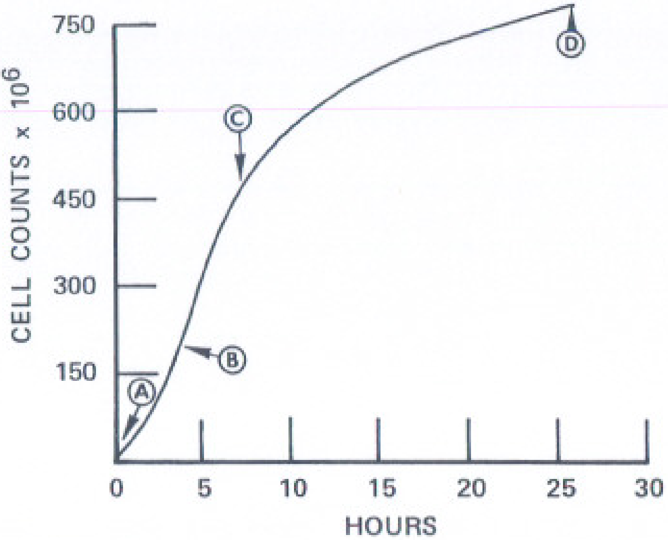

Figure 1. Cell Counts of *S. fragilis* Grown in Whey at 95°F and PH 4.8

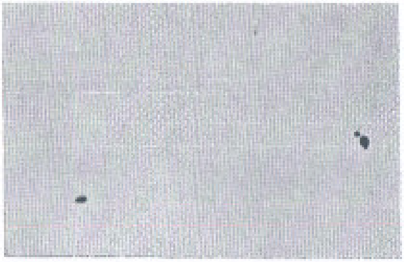

Figure 2. "A": *S. fragilis* at 0 Hours; Average Cell Size, 4.0 x 3.7 u

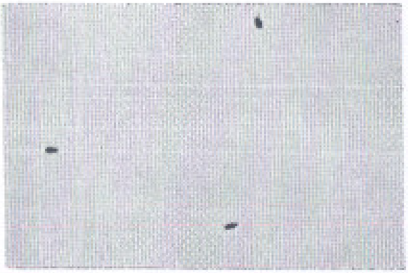

Figure 3. "B": *S. fragilis* at 4 Hours; Average Cell Size 4.8 x 2.6 u

Figure 4. "C": *S. fragilis* at 7 Hours; Average Cell Size 5.3 x 2.4 u

Figure 5. "D": *S. fragilis* at 25½ Hours; Average Cell Size 3.8 x 2.4 u

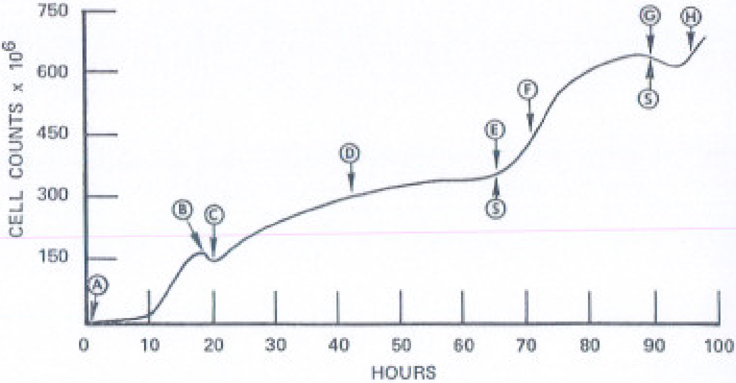

Figure 6. Cell Counts of *Rh. gracilis* Grown in Whey at 95°F and pH 5.0; "S" Indicates 5% Sucrose Feeding after Sampling

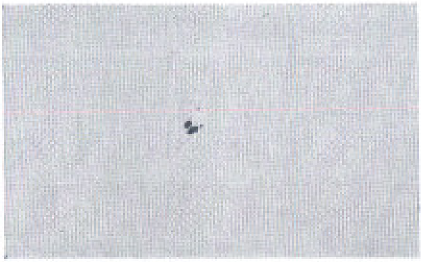

Figure 7. "A": *Rh. gracilis* at 0 Hours; Average Cell Size 3.2 x 2.0 u

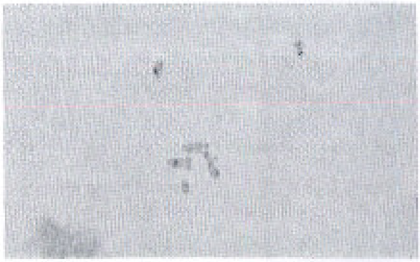

Figure 8. "B": Rh. *Gracilis* at 18¼ Hours; Average Cell Size 6.4 x 3.5 u

Figure 9. "C": *Rh. gracilis* at 20¼ Hours; Average Cell Size 4.7 x 2.0 u

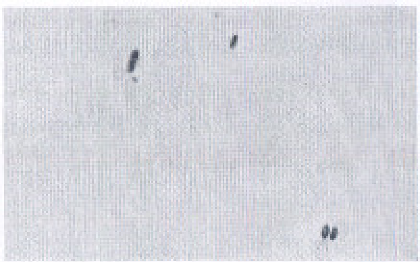

Figure 10. "D": *Rh. gracilis* at 42¼ Hours; Average Cell Size 6.5 x 3.8 u

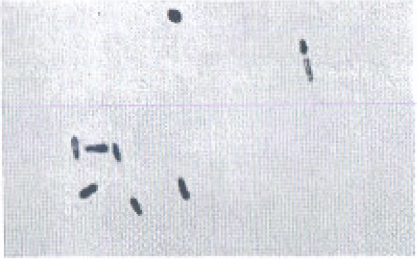

Figure 11. "E": *Rh. gracilis* at 66¼ Hours; Average Cell Size 5.2 x 3.0 u

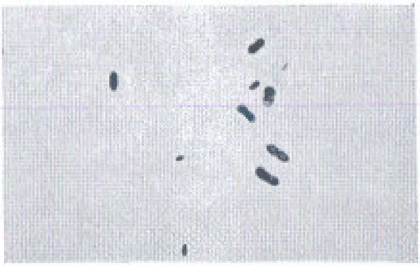

Figure 12. "F": *Rh. gracilis* at 71 Hours; Average Cell Size 6.4 x 3.0 u

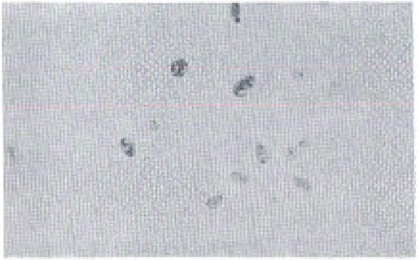

Figure 13. "G": *Rh. gracilis* at 90¼ Hours; Average Cell Size 6.4 x 4.2 u

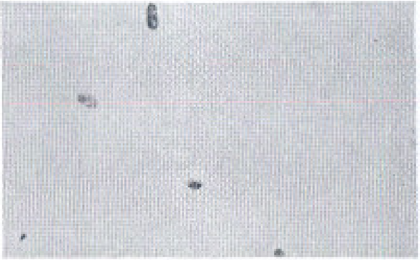

Figure 14. "H": *Rh. gracilis* at 96 Hours; Average Cell Size 7.0 x 4.4. u

With increasing age, the cell walls of the *Rh. gracilis* yeasts became progressively thicker as noted by other investigators (4). This was especially noticable in Figures 8, 10, and 13, taken after the yeasts had been growing 18, 42, and 90 hours respectively. Staining with Sudan Black B confirmed the presence of fat-containing vacuoles in the cells.

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Other Related Projects

Changes in Postweaning feed Efficiency As a Result of Selection for increased Preweaning and Postweaning Growth Rate in Mice

M. A. Brown and R. R Frahm

Story in Brief

Growth performance to six weeks of age and feed efficiency between 21 and 42 days were determined for mice from three types of selection lines after 11 generations of selection. The three types of selection lines were: unselected control lines (CL), lines selected for increased weaning weight at 21-days of age (WWL) and lines selected for increased rate of gain between 21 and 42 days of age (ADGL). The WWL required more feed per unit of gain between 21 and 42 days of age than the CL, whereas the ADGL required less feed per unit of gain than the CL.

Both the WWL and ADGL significantly exceeded the CL in 21-day weight, 42-day weight, 21-42 day average gain and 21-42 day average daily feed consumption. The WWL were heavier at 21 days than the ADGL, but were lighter at 42 days of age, and gained slower from 21-42 days of age. Although the ADGL consumed more feed per day, they had a sufficiently larger rate of gain from 21-42 days of age that they required 1.3 grams less feed per gram of gain than did the WWL.

Introduction

One of the major factors in feeding farm animals profitably is to minimize total cost per unit gain. A large component of this total cost is the amount of feed required per unit gain of body weight. Although feed efficiency is a very important trait, it has generally not been measured or selected for in most performance testing and selection programs used by the livestock industry. This is primarily because of the difficulty and expense of determining feed efficiency on an individual basis. Some measurement of growth rate has been one of the principle traits involved in most livestock breeding programs designed to improve the genetic capability of the population for increased productivity. Fortunately, most research results, both with livestock and laboratory species, have shown a favorable genetic relationship between increased growth rate and feed efficiency. Thus, to some extent, increased growth rate resulting from selection should also be accompanied by an improvement in feed efficiency.

A laboratory organism, such as mice, can be very useful in terms of ascertaining the genetic interrelationships that exist between various performance traits. Such experiments with mice can involve a larger number of animals under more carefully controlled environmental conditions for less total cost than is possible with the livestock species. In addition, the shorter generation interval of mice (3 months) allows the experiment to be conducted in a much shorter time. The basic knowledge obtained from such experiments concerning the genetic interrelationships that exist for the economically important performance traits will aid in the development of more effective breeding programs to improve the total performance level of the livestock species.

The components that directly effect efficiency of gain are average daily gain and average daily feed consumption. It is the relationship of these components, with each other and with other performance traits, that must be studied to define the response of efficiency of gain to selection for increased growth performance. The objectives of this study were to determine the correlated change in feed efficiency as a result of selection based on preweaning and postweaning growth rate and to determine the phenotypic relationships that exist among some of the growth performance traits and postweaning feed efficiency in these selection lines.

Materials and Methods

A selection study with mice is currently underway to specifically measure the direct and correlated responses to selection for preweaning and postweaning rate of gain. This study consists of six selection lines (three being selected for increased weaning weight at 21 days of age and three being selected for increased postweaning rate of gain between 21-42 days of age) and two unselected control lines. Each line consists of 20 litters in each generation. A more complete design of the selection study is presented in Okla. Agr. Exp. Sta. Miscell. Pub. 87:184.

The present study reports the growth performance and feed efficiency data after 11 generations of selection. Performances were similar in lines of the same type and thus the data were averaged and/or pooled within each type of selection line. Data are presented and compared by type of selection line: Unselected control lines (CL), weaning weight lines (WWL) and postweaning average daily gain lines (ADGL).

Mice were fed *ad. lib.* on standard Purina Lab Chow pellets. Mice of the same sex from the same line were placed in cages at 21-days of age. It was attempted to have 4 mice in each cage, but this was not possible in all cases. Most cages had 3 or 4 mice per cage. A few had 2 mice per cage and occasionally it was necessary to have only 1 mouse in a cage. The growth performance and feed efficiency for the single mouse cages were quite similar to the multi-mouse cages of the same selection group, thus their data were included in the analysis. The total number of mice and cages for each selection group are presented in Table 1.

Total feed consumption was measured for each cage of mice between 21-42 days of age. The postweaning period of 21-42 days in mice is a period of rapid growth rate and would be somewhat comparable to the feeding phase of the livestock species. All feed was carefully sifted to

Table 1. Average Performance by Type of Selection Line After 11 Generations of Selection

	Control Lines	Weaning Wt. Lines	21-42 Day ADG Lines	Pooled Stand. Dev.
No. Cages	80	133	126	
No. Mice	291	463	429	
21-Day Weight (gms.)	9.9[1]	12.2[2] (23.23%)[4]	11.3[3] (14.14%)	1.106
42-Day Weight (gms.)	23.4[1]	27.0[2] (15.38%)	31.4[3] (34.19%)	1.648
21-42 Day ADG (gms./day)	0.64[1]	0.71[2] (10.94%)	0.96[3] (50.00%)	0.056
21-42 Day Daily Feed Consumption (gms.)	3.94[1]	4.64[2] (17.77%)	5.09[3] (29.19%)	0.493
21-42 Day Feed Efficiency (gms. of feed/gm. of gain)	6.22[1]	6.70[2] (7.72%)	5.38[3] (−13.50%)	0.666

[1,2,3] Means on the same line with different superscripts were significantly different ($P < .01$).
[4] Parenthetical percentages are the deviation from the control group expressed as a percentage of the control.
[5] Author omitted.

eliminate fine material from the pellets in order to minimize feed waste. Feed consumption, and consequently feed efficiency, were determined on a cage basis. Since the number of mice per cage varied, the data were analyzed on an average per mouse per cage basis.

The data were analyzed and summarized for males and females, separately. The comparisons between selection lines were very similar for both sexes; and thus, the data were averaged over both sexes for presentation of the results.

Results and Discussion

The mean performances for each of the three selection groups after 11 generations of selection are presented in Table 1. Both the weaning weight lines (WWL) and postweaning average daily gain lines (ADGL) exceeded the control lines (CL) for 21-day weight, 42-day weight, 21-42 average daily gain and 21-42 day average daily feed consumption. The WWL had a significant decrease in feed efficiency as compared to the CL, whereas, the ADGL showed a significant improvement in feed efficiency. The WWL had significantly heavier weaning weights at 21-days of age than the ADGL, but were lighter at 42 days of age and gained more slowly from 21-42 days. Although the ADGL consumed more feed per day on the average than the WWL, they gained sufficiently faster from 21-42 days of age such that 1.32 fewer grams of feed were required per gram of gain.

The phenotypic correlations between traits within each selection group are presented in Table 2. Within all three selection groups, the positive correlation coefficients for 21-day weight and 21-42 day daily feed consumption with feed efficiency indicate an antagonistic relationship. Heavy weaning weights and increased daily feed consumption tend to be associated with an increased feed requirement per unit of gain. The negative correlation between 21-42 day ADG and feed efficiency indicates a favorable relationship. Increased 21-42 day average daily gain tends to be associated with improved feed efficiency. The correlations indicate a stronger relationship between feed consumption and feed efficiency than between 21-42 day average daily gain and feed efficiency. As would be logically expected, the best feed efficiency would be expected among the most rapidly gaining animals that have lower feed consumption rates.

Selection for 21-day weaning weight and selection for postweaning average daily gain apparently has resulted in some alteration in the relationships among 21-42 day average daily gain, daily feed consumption, and feed efficiency such that the feed efficiency performance was markedly different in the three groups after 11 generations of selection.

Table 2. Phenotypic Correlations Between Certain Performance Traits within Each Type of Selection Line

	21-Day Wt.	42-Day Wt.	21-42 Day ADG	21-42 Day Daily Feed Cons.
42-Day Wt.:				
CL[3]	0.752[1]			
WWL[3]	0.647[1]			
ADGL[3]	0.666[1]			
21-42 Day ADG:				
CL	0.006	0.650[1]		
WWL	0.086	0.812[1]		
ADGL	−0.082	0.677[1]		
21-42 Day Daily Feed Consumption:				
CL	0.286[1]	0.596[1]	0.235	
WWL	0.310[1]	0.451[1]	0.356[2]	
ADGL	0.386[1]	0.394[1]	0.141	
21-42 Day Feed Efficiency:				
CL	0.508[1]	0.019	−0.563[1]	0.678[1]
WWL	0.235	−0.160	−0.385[2]	0.719[1]
ADGL	0.409[1]	−0.039	−0.456[1]	0.811[1]

[1] Correlations significantly different from 0 at the .01 probability level.
[2] Correlations significantly different from 0 at the .05 probability level.
[3] CL, WWL and ADGL refer to the control lines, weaning weight selection lines and 21-42 average daily gain selection lines, respectively.

Part of the difference in feed efficiency between the groups may be due to the nature of the gains within the groups. In the WWL there was a significant correlation between average daily gain and daily feed consumption, suggesting that the higher gaining animals ate more feed. The fact that there were more nutrients passing through the G. I. tract possibly increased the likelihood of more nutrients being absorbed than required for maintenance, thus increasing gain. In the ADGL there was no significant correlation between average daily gain and daily feed consumption. This could mean that the higher gaining animals within the group did not especially eat more feed than the lower gaining animals but had a better ability to absorb what nutrients were present, thus exceeding their maintenance requirements to gain weight.

Since daily feed consumption had an adverse effect on feed efficiency that was apparently of larger magnitude than the beneficial effect of increased average daily gain, it might be expected that increased average daily gains caused by increased feed consumption would result in poorer feed efficiency. It would also be expected that increased gains due to increased feed absorption would result in better feed efficiency.

Another part of the differences in feed efficiency could be due to the differences that exist in 21-day weight. The correlations between 21-day weight and feed consumption suggest that an increase in 21-day weight would also increase daily feed consumption. The WWL were the heaviest at 21-days, and thus, their postweaning feed efficiency should be more adversely effected. Increased 21-day weight could also possibly increase maintenance requirements, and consequently have an adverse effect on postweaning feed efficiency.

These data clearly indicate that selection for increased postweaning rate of gain has significantly improved efficiency of gain. On the other hand, increasing weaning weight through selection has been accompanied by an apparent reduction in feed efficiency. Further study of basic biological components such as the body composition of the weight changes and nutrient absorption rates will be necessary to more clearly explain the relationship between feed efficiency and the growth performance traits.

SUMMARY REPORTS

Other Research in Progress

Cow-Calf-Stockers

Selection for Increased Growth Performance in Beef Cattle

R. R. Frahm and Glenn Selk

In order to meet the projected increase in consumer demand for beef and to realize a profit in spite of increasing production costs, cattlemen face a tremendous challenge to increase the level of production per cow in the breeding herd. Since the total quantity of beef produced has a direct bearing on realized profits, cattlement are justifiably concerned about the growth rate of their cattle. Consequently, some measure of growth rate is one of the principle traits utilized in performance testing and selection programs.

The beef cattle selection study initiated in 1964 at the Ft. Reno Livestock Research Station involves both purebred Angus and Hereford cattle. The objective of this study is to determine the direct and correlated genetic responses to selection based on weaning weight and yearling weight, respectively.

The study consists of six selection lines of 50 cows each: two Hereford lines (one selected for increased weaning weight and the other selected for increased yearling weight) and four Angus lines (one selected for increased weaning weight, one selected for increased yearling weight, one selected for increased weaning weight based on progeny test information and one serves as an unselected control line). A more complete experimental design for this study is presented in Okla. Agr. Exp. Sta. Misc. Pub. 85:150.

It is too early in the study to determine the actual rate of genetic improvement resulting from selection. However, it is apparent that thus far in the study no major differences in growth performance as measured by weaning weight or yearling weight have occurred between the weaning weight and yearling weight selection lines within either breed. This implies that the genetic changes that have occurred thus far for growth performance have been similar in both the weaning weight and yearling weight lines.

Examination of the growth performance of the selected bulls gives some indication of why the weaning weight and yearling weight lines are performing at a similar level. The 10 Hereford bulls selected and used in the weaning weight line during the past five years had an average 205-day weaning weight ratio of 1.17 and a yearling weight ratio of 1.12. The 10 Angus bulls selected in the weaning weight line had an average weaning weight ratio of 1.13 and a yearling weight ratio of 1.08. Although these bulls were selected on the basis of weaning weight performance they also had a higher genetic potential for heavy yearling weight than the average of the line.

The weaning weight and yearling weight ratios for the 10 Hereford bulls selected in the yearling weight line were 1.13 and 1.16, respectively and 1.09 and 1.13, respectively, for the 10 bulls selected in the Angus yearling weight line. Use of any of these 4 sets of bulls would be expected to increase both weaning weight and yearling weight in their respective lines.

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Comparison of Cow Productivity Among Certain Two-Breed Crosses

R. R. Frahm and Todd Stanforth

Research has clearly demonstrated that crossbreeding among the traditional beef breeds in the U.S. can increase production in terms of pounds of calf weaned per cow exposed for breeding by at least 15 percent. Crossbreeding improves production by providing an opportunity to capitalize on combining the desirable characteristics of two or more breeds and by taking advantage of heterosis.

The amount of heterosis expressed for a particular trait is dependent upon the genetic differences between the breeds involved and the amount of non-additive genetic variation for that trait. Thus, heterosis is expected to be larger, and has generally been found to be larger, for traits with a low heritability such as those traits involved with reproductive efficiency and maternal performance of the cow and early growth rate of the calf. Consequently, the crossbred cow is an essential component of increased production through crossbreeding.

Adequate numbers of straightbred animals of many of the more recently imported breeds are not available to determine the actual level of heterosis resulting from crossing with the more traditional breeds. However, it is possible to compare the level of performance of these crossbreds with existing breeding stock to determine the merit of these imported breeds for total production under management systems that exist in the U.S.

The purpose of this study is to compare lifetime productivity under range conditions of eight different two-breed cross cow groups (Angus-Hereford, Hereford-Angus, Simmental-Angus, Simmental-Hereford, Brown Swiss-Angus, Brown Swiss-Hereford, Jersey-Angus and Jersey-Hereford) when mated to terminal cross sires of a third breed. Each of the eight crossbred cow groups will consist of approximately 45 cows resulting from appropriate matings to comparable sets of Angus and Hereford cows over a three year period.

A foundation herd of approximately 200 Angus and 200 Hereford cows that are typical of good commercial cattle in Oklahoma were assembled at the Lake Carl Blackwell research range near Stillwater and were bred to the respective sire breeds during the 1972 breeding season to produce the first set of crossbred calves during February - April of 1973. Lifetime productivity of each crossbred cow group (approximately 10 calf crops) will be compared when mated to the same set of sires of a breed other than those involved in the composition of the cows.

Feedlot performance and carcass merit will be measured on the two-breed cross steers as well as on the three-breed cross calves that will be produced by the crossbred cows. Shorthorn and Red Poll bulls will be used to sire the calves produced by the crossbred cows as 2-year-olds. Charolais bulls will be used for the second and subsequent calves until the three different age groups of crossbred cows all reach maturity. At that time one other breed can be introduced in any one year for comparison with Charolais as a terminal cross sire breed.

Data will be collected on reproductive and maternal performance of cows, winter supplementation and total nutritional requirements of cows, growth rate of calves to weaning, and feedlot performance and carcass evaluation of the calves.

Results from this study will provide basic information that will be essential in developing systematic crossbreeding programs utilizing available genetic resources (breeds) that will optimize production under Oklahoma range conditions.

Problems Associated with Induced Superovulation and Superfetation in Beef Cows

E. J. Turman, J. G. MaGee, M. R. Johnson and D. F. Stephens

Previous research carried out as a part of this project has demonstrated that the incidence of multiple births in beef cattle can be greatly increased by the injection of the gonadotropic hormone preparations PMS and HCG. In early studies the PMS injections were given on days 5 and 17 of the estrual cycle timed from a naturally occurring estrus. However, as reported elsewhere in this publication, the PMS injections may be timed from a synchronized estrus.

The HCG injections have been given at, or near, the first post-PMS estrus to insure that all follicles stimulated by the PMS will be ovulated. However, there is some question as to whether there is a need for additional leutinizing hormone, which is the predominant gonadotropic hormone found in HCG. Accordingly, a small study was carried out in the spring of 1971 to test whether this injection was needed.

Thirty-one lactating cows were checked for the occurrence of estrus and injected subcutaneously with 1000 IU PMS on day-5 and 1500 IU PMS on day-17 of the cycle counting the day of estrus as day-0. Following the second PMS injection the cows were placed with fertile bulls. As the cows were observed to be in estrus they were alternately assigned to either receive HCG or not receive HCG. Only 14 of the 31 cows were observed in estrus, therefore, only seven cows were assigned to each group. However, at least seven additional cows were in estrus, but not observed, since they conceived at this estrus, resulting in data in 14 cows not receiving HCG, but on only seven receiving HCG.

Of the seven cows receiving HCG, one conceived at the first post-PMS estrus and produced twins. Of the 14 cows not receiving HCG, 10 conceived and produced 5 singles, 3 sets of twins and 2 sets of triplets. While numbers of animals are too small to permit definite conclusions, these results suggest that the HCG injections are not necessary.

Publications

Turman, E. J., J. G. MaGee and D. F. Stephens. 1972. Weaning more calves per cow. Okla. Agr. Exp. Sta. Res. Rpt. P-673:1.

Meat and Carcass Evaluation

A Method for Measuring Shear Force for An Individual Muscle Fiber

R. L. Henrickson, R. D. Morrison and J. L. Marsden

Abstract

The microsensitive shear instrument, a device designed to measure the shear force of individual muscle fibers, was elvaluated in a uniformity trial, and in a comparison of bovine Sartorius muscle excised after being conditioned in the carcass for 2, 5, and 8 hours, at 16° C. Each of 299 randomly drawn fibers were evaluated for diameter, percent kinkiness, and shear force.

In a comparison of "cold" excised Sartorius muscle fibers and Sartorius fibers conditioned for 2, 5, and 8 hours post-morten, 3600 fibers were evaluated for diameter, percent kinkiness, and shear force. Data from the uniformity trial established the feasibility of measuring shear force for individual muscle fibers. The mean shear force for the 299 fibers was 2.30 gm./U^2.

In the comparison of the Sartorius muscle excised "Cold" and those excised after 2, 5, and 8 hours post-mortem, a difference was found to be statistically significant (P 0.01) for the 2 hour post-mortem holding period for diameter, percent kinkiness, and shear force. At the 5 and 8 hour conditioning periods, no significant differences were detected for the three fiber parameters.

The Potassium Concentration in Four Major Protein Fractions of Bovine Longissimus Muscle

J. J. Guenther, J. R. Escoubas and J. D. Gresham

Total muscle, or fat-free lean, and total muscle potassium are, purportedly, highly correlated. In fact, this concept forms the basis upon which various prediction equations to estimate total fat-free lean in live animals, via live animal ^{40}K analysis, have been developed. This apparent importance of and extensive use of total muscle potassium in estimating the lean content of breeding stock has prompted the authors to determine the concentration of potassium in the major protein fractions comprising whole muscle.

For this study, samples of longissimus muscle were obtained from ten mature beef steers. The steers were of the choice grade and averaged 432 kg. alive. Following procedures developed in our laboratory the muscle samples were partitioned into the following protein fractions: Sarcoplasmic; Myofibrillar; Stroma and Lipo-protein. The potassium concentration of each of these fractions was determined by Atomic Absorption Spectroscopy. Digestion of the protein fractions was accomplished in a perchloric (70 percent) -nitric acid mixture (3:1). Results were expressed as milligrams potassium per gram of wet tissue.

The mean values from the muscle potassium analyses are shown in Table 1. These results are presented on an absolute as well as on a percentage basis. The data show that whole bovine longissimus muscle contains about 3.612 mg potassium per gram of tissue. It is obvious from these results that muscle potassium is located primarily in the Sarcoplasmic protein fraction of muscle, which contained 3.570 mg K/g. tissue or 98.84 percent of the total muscle potassium. The myofibrillar fraction contained only 0.61 percent of the total potassium, which was a little more than twice the amount found in either the Stroma or Lipoprotein fractions.

These data raise some interesting questions as to the ultimate quantitative and qualitative attributes of meat carcasses if the selection of breeding stock is based too strongly on the muscle potassium: fat-free lean relationship. Further study is planned to elucidate some of these effects.

Table 1. Potassium Concentration in the Major Protein Fractions of Bovine Longissimus Muscle

	Muscle Fraction				
	Total	Sarcoplasmic	Myofibrillar	Stroma	Lipo-Protein
mg. K/g. tissue	3.612[1]	3.570	0.022	0.010	0.010
% of total	100.0	98.84	0.61	0.28	0.28

[1] All values are averages of 10 muscle samples

Use of K^{40} Net Count as a Monitor of Body Composition Changes in Growing and Fattening Beef Cattle and Swine

Lowell E. Walters, T. R. Carr and R. F. Queener

Earlier work at this station dealing with the association between live net K^{40} count and pounds of fat-free lean in the carcass of forty yearling Angus bulls and sixty Yorkshire barrows has stimulated considerable interest in this method as an aid to more effective livestock selection. Results of these and other studies form the basis of prediction equations currently in use with the K^{40} technique at the O.S.U. Live Animal Evaluation Center for appraising 1000 pound beef cattle and 220-240 pound hogs for muscle content on a "custom" evaluation basis as well as for continuing live animal evaluation research.

Among known sources of variation in results from the application of radiation technology to problems of a biological nature, such as with meat animals, are included such variables as sample to detector geometry, size and conformation of the test animals, as well as the age, sex and condition of the animals at the time of evaluation.

Previous research at the Oklahoma Agricultural Experiment Station has been conducted with groups of animals that were as uniform in age, breed, weight and condition as was possible to obtain in order to subject the O.S.U. K^{40} whole-body counter to a critical test of its capability to estimate differences in muscling among meat animals.

Questions have arisen concerning the application of this technique to cattle and swine of younger ages and lighter body weights with the thought that considerable saving in time and expense could possibly be achieved if K^{40} prediction equations were available for such animals. With these thoughts as a background, research is currently in progress which is designed to answer questions pertinent to the application of the principles of radiation technology (K^{40}) to the live evaluation of more youthful, lighter weight beef cattle and swine. The following is the plan of research currently in progress:

Cattle: Ninety-six beef steers representing four weight groups and two body types are being evaluated using new detector arrangements in the O.S.U. K^{40} counter. The arrangement of detectors provides for a radiation monitoring system located as close to the animal as is possible in attempts to improve K^{40} counting efficiency over a range of live weights. In order to accomplish this, new detector hangers have been constructed in accordance with height and width dimensions of the cattle in each of four weight categories.

Three replications of 16 steer calves each weighing approximately 400 pounds and representing "intermediate" beef type are being randomly allotted to slaughter weight groups of 500, 700, 900 and 1100 pounds and placed on feed in the dry lot. From each replication, 4 steers are allotted to each weight group, making a total of 12 "intermediate" type steers for each of the four slaughter weights. Three additional replications of 16 steer calves each weighing approximately 400 pounds and representing "large scale, growthy" beef type are being randomly allotted to slaughter weight groups of 500, 700, 900 and 1100 pounds and placed on feed in the dry lot.

From each replication four steers are being allotted to each weight group, making a total of 12 "large scale, growthy" type steers for each of the four slaughter weight groups. As the steers reach the shrunk live weights of 500, 700, 900 and 1100 pounds, they are taken off-feed for 24 hours, thoroughly washed to remove possible radiation contaminating materials and then evaluated by the K^{40} whole-body counter, using the detector configuration which most closely fits that particular weight and type.

Those steers designated at the outset of the experiment to be slaughtered at a particular weight are moved to the Meat Laboratory for slaughter and carcass evaluation. The carcasses are evaluated for carcass quality and cutability grade along with additional measurements including average fat thickness at 12th rib, rib eye area, weight of boneless, closely trimmed round, loin, rib and chuck, total pounds of fat trim and total boneless, closely trimmed minor wholesale cuts. Chemical analyses for ether-extract and muscle potassium in the boneless closely trimmed muscle mass from the right half of each carcass are in progress. Fat-free lean is determined by subtracting total ether-extractable materials from the weight of the boneless, closely trimmed muscle mass from the right carcass half.

Correlation and regression studies of the association between net K^{40} count and fat-free lean in the animals at different ages and weights will then be made. These studies also include an attempt to describe possible changes in the pattern of potassium concentration in selected beef muscles over a range of ages and live weights in each of the two types. For this purpose, chemical analyses for potassium are being conducted on the longissimus dorsi, trapezius, supraspinatus, semitendinosus and biceps femoris muscles from each carcass. Slaughter and carcass evaluation is nearing completion for Replication I for both types of cattle. A full report of the results will be made at a later date.

Swine: One hundred market barrows (50 Hampshire and 50 Yorkshires) representing five weight groups are being evaluated by the K^{40} whole-body counter. A new detector arrangement is utilized in the counting of the swine in an attempt to improve K^{40} counting efficiency over a range of live weights. The new arrangement of detectors provides for more flexibility in the adaptation of the instrument to pigs over a range of live weights from 100 to 300 pounds than has been possible in previous swine studies.

Ten replications of 10 feeder pigs each weighing 60-70 pounds are randomly allotted to slaughter weight groups of 100, 150, 200, 250 and 300 pounds and placed on a growing-fattening ration. From each replication, two pigs are randomly assigned to each slaughter weight group, making a total of 20 pigs for each of the five slaughter weights as is shown in Table 1.

As the pigs reach the shrunk live weights of 100, 150, 200, 250 and 300 pounds, they are taken off-feed for 24 hours, thoroughly washed to remove any foreign material that might influence the K^{40} count and then evaluated by the K^{40} whole-body counter, using the dector configuration which most nearly fits that particular weight. Those pigs which were designated at the beginning of the experiment to be slaughtered at a particular weight are taken to the Meat Laboratory for slaughter and carcass evaluation. Live animal measurements taken are a whole-body K^{40} count and a lean-meter probe. Carcass measurements taken include length, average backfat, loin eye area, weight of trimmed ham, loin and shoulder, weight of total fat trim, and weight of boneless, closely trimmed lean from the right carcass half.

Ether-extract and potassium analyses are conducted on ground lean samples of the right carcass halves and total pounds of fat-free lean are determined by difference. In addition, the biceps femoris, semimembranosus, and longissimus dorsi muscle are excised and analyzed chemically for potassium and ether-extract.

Table 1. Experimental Design

Replication	Slaughter Weight Groups (pounds)				
	100	150	200	250	300
I	2[1]	2	2	2	2
II	2	2	2	2	2
–	–	–	–	–	–
–	–	–	–	–	–
–	–	–	–	–	–
–	–	–	–	–	–
X	2	2	2	2	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.

Two replications of this work have been completed and one-half of the animals involved in Replications III, IV, V and VI have been slaughtered. Ether-extract and potassium analyses have been conducted on the muscle samples taken from the lean of those animals in Replications I and II. Statistical analysis of the data will be conducted.

Preliminary Results:

While statistical analyses are not available at this time, graphic plots of certain of the data point to trends in the data and are presented in Figures 1 and 2.

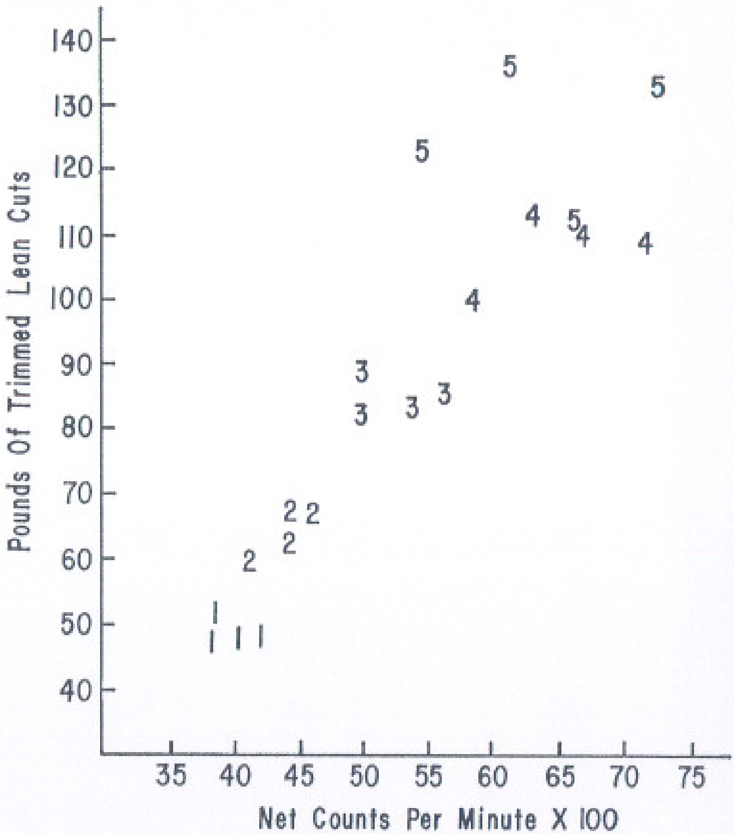

Figure 1. Net K^{40} count and weight group as related to pounds of closely trimmed lean cuts.

The plotted numbers 1, 2, 3, 4 and 5 represent animals in the weight groups 100, 150, 200, 250 and 300 pounds, respectively.

The plot of net K^{40} count, live weight and pounds of closely trimmed lean cuts is presented in Figure 1. There appears to be a rather strong positive linear relationship between K^{40} count and total pounds of closely trimmed lean cuts.

These preliminary data suggest that as slaughter weights of the pigs increase, there is greater variation in pounds of lean cuts among animals of the same weight group. Some of this variation may be "real" while a portion may be attributable to one's inability to remove equal amounts of intermuscular fat from the lean cuts. The inability to remove any of the intramuscular fat (marbling) from the lean cuts may also be a source of variation. At least a part of this variation is to be expected, inasmuch as pigs in the 100 pound group are much leaner (i.e., have a

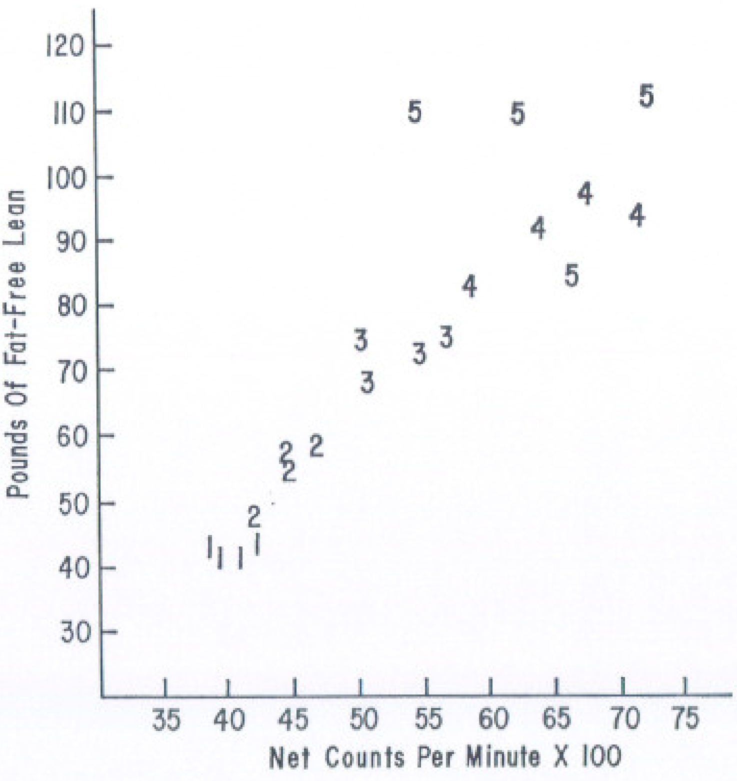

Figure 2. Net K^{40} count and weight group as related to pounds of fat-free lean.

The plotted numbers 1, 2, 3, 4 and 5 represent animals in the weight groups 100, 150, 200, 250 and 300 pounds, respectively.

much lower fat to lean ratio) than those of the 250 and 300 pound groups.

In lean and fat separation, one is able to remove much more fat proportionately from the cuts of the carcass from the 100 pound pig than from those in the heavier weights. Thus, lean cuts from heavier weight groups are not as good an estimator of carcass muscle as are those from the lighter weight groups of pigs.

A plot of net K^{40} counts, live weight and pounds of fat-free lean from pigs in Replications I and II is presented in Figure 2. The plot of these data suggests a rather strong positive linear relationship between pounds of fat-free lean and net K^{40} count in each of the five weight groups. There appears to be greater variation in pounds of fat-free lean among animals in the heavier weight groups than in the light weight groups. Further, the association between K^{40} net count and pounds of fat-free lean does not appear to be as strong at live weights of near 300 pounds as is apparent in the lighter weights.

A part of this variation among animals in heavier weights may be attributed to the self-absorption of gamma rays emitted from the muscle in the animal. The larger the animal, the greater is the likelihood that a gamma ray will lose part of its energy before leaving the animal and interacting with the detectors thus reducing the number of disintegrations detected.

Another possible source of variation may involve the fat. We do not know, for example, to what extent a layer of fat may act as a shield, thus influencing the number of gamma rays that have sufficient levels of energy to pass through the animal mass and become detectable.

While the plots of the data in Figures 1 and 2 are quite similar, there appears to be a greater linear trend in the 100, 150, 200 and 250 pound groups in fat-free lean estimation than for that of trimmed lean cuts. A complete report of the results of this study will be made at a later date.

Swine

Influence of Heat Stress on Reproductive Performance of Boars

R. P. Wettemann, I. T. Omtvedt, M. E. Wells,
C. E. Pope, E. J. Turman and T. W. Williams

Decreased conception rates and increased breeding problems occur in swine herds during the summer months. This decrease in reproductive efficiency may be a result of elevated ambient temperature on the boar since gilts exposed to heat stress prior to breeding tend to have normal reproductive performance.

The objective of this study is to evaluate changes in semen quality, testicular physiology, hormone secretion and fertility of boars exposed to high ambient temperatures. A total of 12 yearling boars that previously produced fertile matings and 180 gilts will be used in this study.

The project was initiated in the fall of 1972. In the first replicate, three boars were randomly allotted to each of the two temperature-controlled environmental chambers at the Fort Reno Experiment Station. Boars were given a 15-day adjustment period at 74°F. On day 15, the temperature in one chamber was elevated to 94°±2°F for 8 hours and lowered to 88°±2°F for the remaining 16 hours during each 24 hr. period. The temperature in the other chamber (control) was maintained at 74°F continuously. Boars in both chambers were exposed to 12 hours of light daily.

Semen quality for each boar was evaluated twice weekly for six weeks during heat stress. After the boars had been maintained under these conditions throughout one complete spermatogenic cycle (42 days), the semen from each boar was used to artifically inseminate 15 sexually mature crossbred gilts. Ninety days after the boars were first subjected to the elevated temperatures, all six boars were castrated and testicular and epididymal evaluations were made. Gilts were slaughtered 30 days postbreeding and their reproductive tracts were recovered to evaluate fertility, embryo survival and early embryo development.

The second replicate of this project will be completed during 1973 and the data now available are too limited to make definite conclusions on the influence of heat stress on fertility in boars. In general, rectal temperatures and respiration rates of boars increased due to elevated ambient temperature. Within two weeks the boars partially compensated to the elevated temperature and rectal temperatures decreased slightly but respiration rates were still elevated. Semen was collected from all boars during the treatment period, but sperm motility was decreased and there was an increase in the percentage of aged acrosomes.

Dairy

The Undesirable Flavor in Milk Resulting From Grazing Cows on Wheat Pasture

P. E. Johnson, L. J. Bush, G. V. Odell and E. L. Smith

In Oklahoma and other states of the Southwest, wheat is a very important pasture crop for the grazing of livestock. It is used by dairymen to a limited extent and would be used much more extensively if it did not cause a very objectional flavor in milk. The occurrence of wheat flavor in milk is highly inconsistant. Some dairymen seem never to have difficulty with the problem while others experience the problem even when they practice all recommended control measures. The only solution of their problem is complete abandonment of wheat pasture. The inconsistency in the occurrence of the wheat problem has been responsible for serious economic losses to Oklahoma dairymen. During February, 1972, several tanker loads of milk were rejected because of wheat flavor. On one single day, eleven tanker loads were rejected in Oklahoma City. The problem is most severe in February but not to the same degree each year.

There appear to be many variables associated with the wheat problem. Some of the more important ones appear to be individuality of cows, stage and rate of growth of the wheat plants, the influence of freezing on the wheat plant, feeding and management practices on the dairy farm, etc.

The objectives of this study are: 1. To study the effect of such variables as stage and rate of growth of wheat pasture, the time grazing, and concentrateforage ratio on the production of wheat flavor in milk. 2. To isolate, and quantitatively measure chemical compound (s) in milk and wheat pasture samples responsible for objectionable flavor in milk. 3. To develop a simple, reliable field test to aid in the detection of wheat flavor. To date, some of these objectives have been accomplished, and the study is continuing.

Triumph 64 wheat was seeded September 15, 1972; and the grazing studies began on November 15, 1972. Twelve Holstein cows were used in this study. They were assigned at random to three groups of four cows each. All groups received the same treatment except for grazing on wheat pasture. Group I was never allowed to graze. Group II was allowed to graze for 30 minutes, and Group III was allowed to graze for 120 minutes. Both groups were removed from pasture two hours before milking. Milk samples were collected from each of the 12 cows at milking time; and, in addition, the entire quantity of milk produced by Cow No. 296 of Group III was collected. The 12 individual milk samples were divided into two portions, and these 24 portions were randomized and coded before they were examined by four experienced milk judges. The judges first examined each sample by tasting and again by smelling the samples after they had rendered slightly basic by the addition of NaOH. The quantity of milk from Cow No. 296 was analyzed for compound (s) responsible for the wheat flavor. This procedure is described briefly as follows: The milk was made basic by the addition of NaOH to release the volatiles believed to be responsible for wheat flavor. A stream of nitrogen was bubbled slowly through the milk for several hours. The nitrogen carried the volatiles from the milk into a series of traps which were charged with a weak HGI solution. The contents of the traps were concentrated and held cold until crystals appeared. The crystals were analyzed by mass spectrophotometry. Similar work is underway on wheat samples and work on other objectives will be started shortly.

The results of the organoliptic evaluations of milk produced by the three groups of cows are summarized in Figure 1. The observations made by smelling alone were more uniform than those made by tasting. The distinction between the two groups which were grazed on wheat and the control group is also more striking. The irregularities occurring in Trial 7 are, no doubt, due to a coating of ice on the wheat plants on this particular day. The intensity of wheat flavor was generally somewhat greater for Group III than it was for Group II, indicating the influence of length of grazing time. The flavor intensity for Group I increased somewhat during Trials 4 through 7, which corresponds to a period when weather conditions grew increasingly worse. During this period, it was impossible to keep lots and shelters

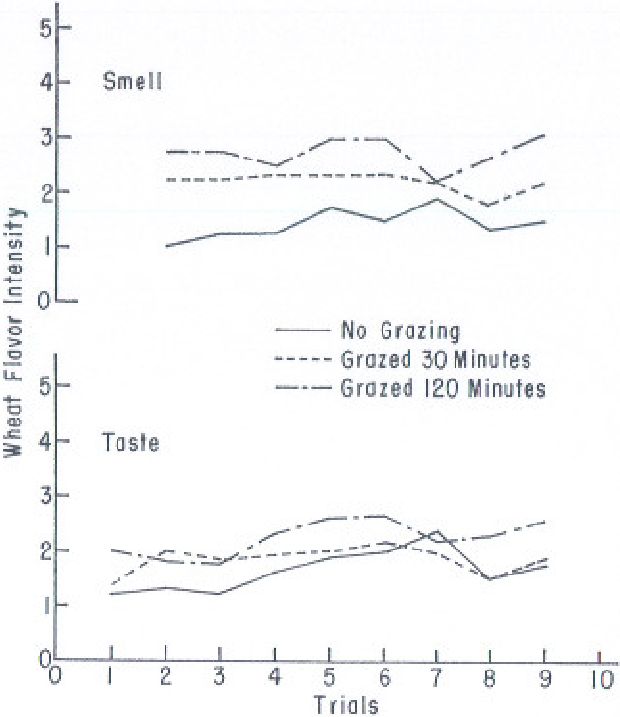

Figure 1. Average wheat flavor intensity in milk from cows grazed on wheat pasture.

in a satisfactorily condition, and the cows were forced to breath air that was contaminated with undesirable odors which might have been transferred to their milk. These odors are believed to have interfered with the judges ability to identify wheat flavor. The fact that this condition was more striking in the taste evaluations than it was in the smell evaluations further supports this premise.

The difference in the tendency of individual cows to impart wheat flavor into milk was also observed in this study. Table 1 shows average flavor intensity ranges between the individual cows of each group. Since an intensity value of 1.0 indicates no detectable wheat flavor and 2.0 indicates a very slight wheat flavor, it can be concluded that no wheat flavor occurred in Group I. Table 1 also indicates that there were individuals in both Group II and III with average flavor intensities of less than 2.0, but there were certain trials when each

Table 1. Range Between Average Flavor Intensities of Individual Cows

Group	Range	
	Taste	Smell
I	1.5-1.7	1.3-1.6
II	1.6-2.3	1.9-2.5
III	1.6-2.6	2.5-3.1

individual cow of both groups produced milk with a definite wheat flavor. Cow No. 296 never produced milk that was free from wheat flavor. This was true for Trial 7 when the wheat plants were covered with ice. The average flavor evaluations on her milk by the four judges on this date were 2.6 for taste and 3.0 for smell.

The analyses by mass spectrophotometry has definitely identified a single compound, trimethylamine, as being responsible for wheat flavor in milk. This development will be extremely valuable in further research on Oklahoma's No. 1 milk flavor problem.

Dairy Foods

Emulsifiers in Foods for the Elderly

J. B. Mickle, Wanda Smith, Sue Knight and Olive Pryor

During the last 12 years, research concerning emulsifiers in foods at O.S.U. has resulted in several new products including low calorie spreads, new cake shortenings, and candy bases. These studies with emulsifiers are continuing, and the objective of this research is to develop ideas which can be used to manufacture foods for the elderly of our population.

Present studies are aimed toward the development of high protein puddings which will be acceptable to the elderly. As a first step in this work, pudding and custard recipes were obtained from cookbooks that were from 40-80 years old. Dishes prepared from these recipes have a taste, texture, and aroma which are familiar to the elderly people. Analyses indicated that a high proportion of the calories came from carbohydrates. Analyses of the canned puddings currently available on the market for elderly people showed that these also had a high proportion of carbohydrate calories and a low proportion of protein calories.

In addition, this survey also revealed that present-day puddings had a rather mild taste and that the textures were sometimes undesirable, in some cases being too watery to stay on the spoon. The recipes from the old cookbooks were then changed to lower the percentage of calories obtained from carbohydrates and to increase the percentage from protein. It is now possible to make a pudding with more than twice the protein content of available commercial puddings but which still seems to have an acceptable texture and taste.

For any food to have wide acceptance among the elderly, it must be appetizing as well as moderate in price. Thus, any protein additives must be relatively inexpensive. This first work has been accomplished using non-fat dry milk solids. Future work will involve whey solids and other inexpensive sources of high quality protein.

Taste panel trials have been arranged so that these puddings can be tasted by a variety of elderly groups: a group of retired but still active people, a group of older people who are relatively inactive, and a group confined to rest homes. The taste panel work will be divided into two parts. First we will determine what types of flavors these people seem to prefer. Then the knowledge of stabilizers and emulsifiers acquired in this laboratory will be used to modify the product so that it has a texture that is appealing to these people. After determining the proper texture and flavor, modifications will be made so that the product will retain this texture and flavor during heat processing and prolonged storage.

Poultry Nutrition

Lipid Metabolism in Laying Hens

Rollin H. Thayer, E. C. Nelson, R. D. Morrison and A. L. Malle

The laying hen is unique with respect to lipid biosynthesis. The yolk in a two ounce egg contains approximately seven grams of lipid, all of which is synthesized in a 20 gram liver, transported to the ovary, and deposited in the yolk. With the introduction of management procedures involving individually caged layers and the development through poultry breeding of hybrid strains of laying hens, difficulties have been encountered which may be related to lipid biosynthesis and/or transport. The result is an excessive accumulation of lipid in the liver, abdominal cavity, and intestinal mesentary. In addition, the liver may have hematomas and hemorrhages. Under commercial production conditions substantial economic losses are suffered by egg producers when high producing hens develop this condition.

Experimental data are not yet available to describe the series of events which do take place in lipid biosynthesis and transport in the laying hens during the complete laying cycle. Neither is it known at what point this overall situation moves from "normal" to "pathological", and what factors including nutrient intake and confinement may be responsible for the change. Studies designed to provide new data in this area with the laying hen may provide data relavent to corculatory problems in humans which are thought to be associated with lipid metabolism and degree of physical activity.

Caged layers at the Oklahoma Agricultural Experiment Station which were fed a specific layer ration accumulated an excessive amount of lipid in the liver. The condition was further characterized by measuring the changes in the quantity and composition of total lipid, triglyceride, cholesterol, phospholipid, and triglyceride fatty acids present in the liver during an egg production period of 36 weeks. Although the percentage of phospholipid, cholestrol and cholestrol ester remained constant, the total lpid concentration increased at a greater rate than dry liver weight. The increase lipid was due to increased triglyceride concentration. With the onset of egg production, the relative concentration of fatty acids in the triglyceride fraction changed, and by 4 weeks resembled within 1 or 2 percent the relative distribution of fatty acids in egg yolk. Research studies now underway are designed to identify possible changes in fatty acid metabolism and transport within the liver which may develop as the total liver lipid concentration increases.

Nutrient Intake Requirements of Caged Turkey Breeder Hens

Rollin H. Thayer, E. T. Clemens, R. R. Johnson, E. C. Nelson and A. L. Malle

Market turkey producers in Europe are using a management system with turkey breeder hens in which the hens are maintained in laying cages. These breeder hens are relatively small in size with an average body weight of from 8 to 10 pounds. They are prolific layers and produce a large number of eggs with a minimum of feed intake. The breeder toms which are mated to these hens are extremely large, averaging in body weight from 30 to 50 pounds. Fertile hatching eggs are produced through the use of artificial insemination. The market turkeys produced through this mating are intermediate in size and have desirable characteristics from the standpoint of growth, efficiency of feed conversion, and market finish.

This system makes it possible to produce poults at a much lower cost than can be done under floor management conditions. Reduction in poult cost through this means in the United States would bring about a significant decrease in the overall cost of producing market turkeys. For this reason, market turkey producers in the United States are considering this management technique.

Research at Oklahoma State University has been designed to determine the nutrient intake requirements of turkey breeder hens maintained under this management system. Current emphasis is being placed upon protein and energy intake requirements. Data collected to date indicate that these small turkey hens (minihens) require a daily intake of 335 kilocalories of metabolizable energy, and approximately 30 grams of protein. Studies are being conducted to pinpoint more exactly, energy and protein intake requirements and additional studies will be undertaken to determine vitamin and mineral intake requirements.

It is anticipated that data from this project will be of interest to market turkey producers in the United States as they give consideration to the adoption of management procedures in which turkey breeder hens are maintained in cages. The trend in the Poultry Industry in the United States is toward confinement in cages. In-so-far as turkeys are concerned, it required considerable research in all phases of management and nutrition in order to develop procedures to successfully produce market turkeys on a second economic basis under domestic conditions as contrasted to the natural habitat. Difficulties of a similar nature in both management and nutrition are being encountered as poultrymen work toward the development of systems to produce hatching eggs and market turkeys under strict confinement conditions in cages. A great deal of research effort will need to be directed toward the solving of these problems.

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The following is a list of those who have contributed to programs of the Department of Animal Sciences and Industry during the preceding year.

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Edwards Equipment Company, Ponca City, Oklahoma, for providing equipment and service for research purposes.

Elanco Products Company, Division of Eli Lilly Company, Indianapolis, Indiana, for drugs for experimental use.

Eli Lilly and Company, Greenfield Laboratories, Greenfield, Indiana, for providing hormones for multiple birth research.

Farmland Industries, Kansas City, Missouri, for providing financial grants to support research assistantships.

Farr Better Feeds, Guymon, Oklahoma, for providing feed ingredients for nutrition research.

Feed Service Corporation, Crete, Nebraska, provided a tenderometer for use in meat research.

Griffith Laboratories, Chicago, Illinois, furnished cure and flavor ingredients for pork processing research.

Harris Packing Company, Oklahoma City, Oklahoma, for cooperation in obtaining carcass data for research and Extension programs.

Hitch Feedlots, Guymon, Oklahoma, for funds to support studies on grain processing and for compost material for animal waste studies.

Lone Star Gas Co., Dallas, Texas, and NIPAK, Inc. Pryor, Oklahoma, contributed materials and financial aid to studies on non-protein nitrogen utilization.

Maurer-Neuer, Inc., Arkansas City, Kansas, for assistance in obtaining carcass data on experimental cattle.

Merck and Company, Rahway, New Jersey, for providing financial assistance and drugs to support studies on internal parasites in range cattle and lysine for swine nutrition research.

Merry Lea Corporation, Kansas City, Missouri for funds to support studies on nutritive value of animal wastes.

NIPAC Chemical Company, Pryor, Oklahoma, for supplying urea and pure biuret for range cow research.

Oklahoma Feed Manufacturers Association, for providing assistance with the graduate research scholarship program.

Oklahoma Pork Commission for a grant supporting swine research.

Chardo Pierce Micronizing Company, Amarillo, Texas, for supplying a grain micronizing unit for use in nutrition research.

Pfizer Agricultural Division, New York, New York, for providing diethystilbestrol implants, neoterramycin for preconditioning studies.

Proctor and Gamble Co., Cincinnati, Ohio, for materials for studying the feeding value of fats for poultry and swine.

The Prolix Companies, Aliceville, Alabama, and T Bar H Liquid Feeds, Cushing, Oklahoma, for supplying liquid supplement.

Ralph's Packing Company, Perkins, Oklahoma, for assistance in obtaining data on animals slaughtered for research and Extension programs.

Ralston Purina Company, St. Louis, Missouri, for two research fellowships in Animal Nutrition.

Ross Machine and Tool Company, Oklahoma City, Oklahoma, for providing equipment and services for research purposes.

Schwab and Company, Oklahoma City, Oklahoma, for assistance in obtaining swine carcass data for research and Extension programs.

Spies Charolais Ranch, Vinita, Oklahoma, for donating Charolais semen.

Syntex Laboratories, Inc., Palo Alto, California, for providing implants for field trials with beef cattle.

Union Carbide Corporation, Chicago, Illinois, furnished casings used in pork processing research work.

Wetmore Manufacturing Company, Tonkawa, Oklahoma, for the loan of a forage chopper for research work.

Wilson and Company, Oklahoma City, Oklahoma, for assistance in obtaining data on animals slaughtered for research and Extension programs.

CORRECTIONS FOR TABLE 4. MILK PRODUCTION, PAGE 37.

Table 4. Milk Production Data

Item	Hereford		Hereford x Holstein		Holstein		
	Moderate	High	Moderate	High	Moderate	High	Very High
Total lactation yield, lb.	3223	3156	4247	5380	7655	6679	7448
Daily yield, lb.	13.4	13.2	17.7	22.4	31.9	27.8	31.0